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Aviation Week

including Space Technology

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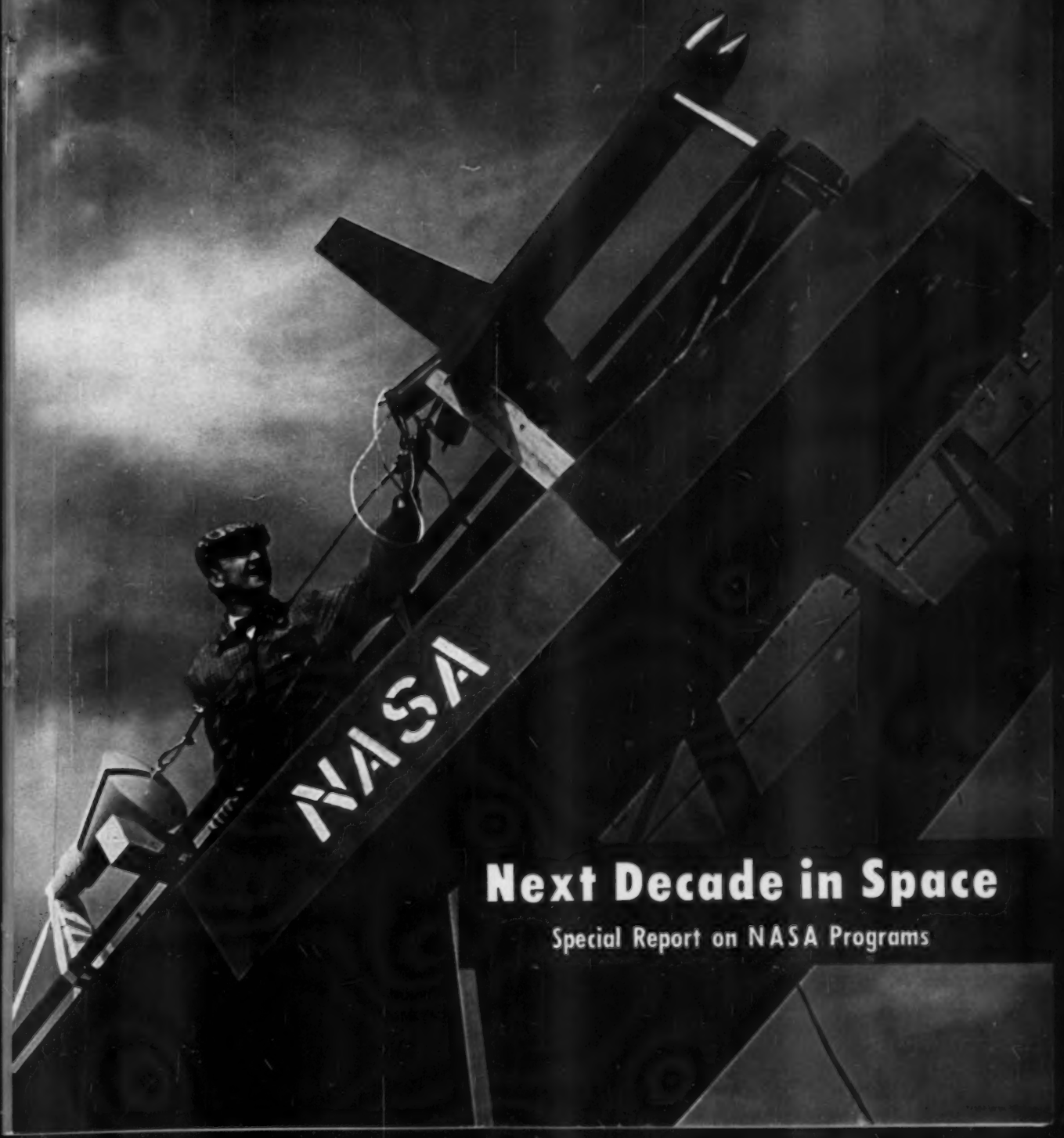

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Special Report on NASA Programs

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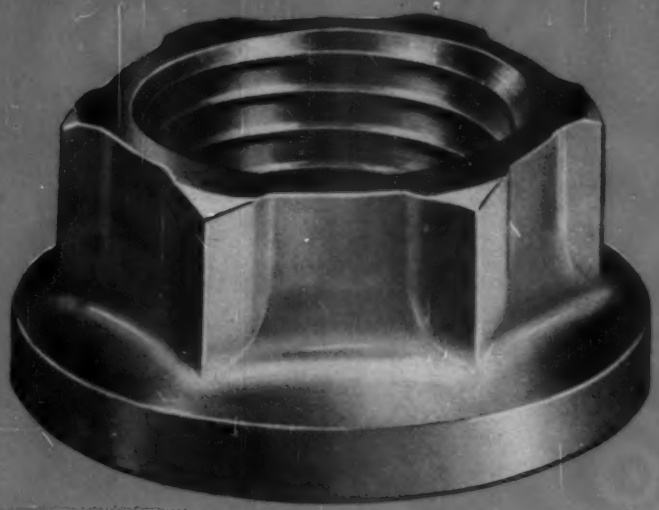
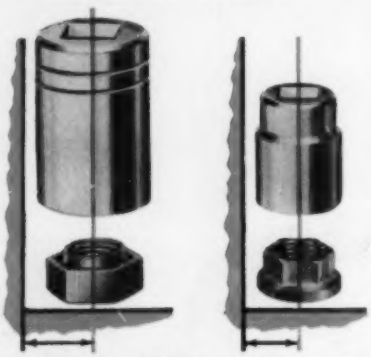


COMPARE WRENCH ACCESS
Standard Hex vs New H14



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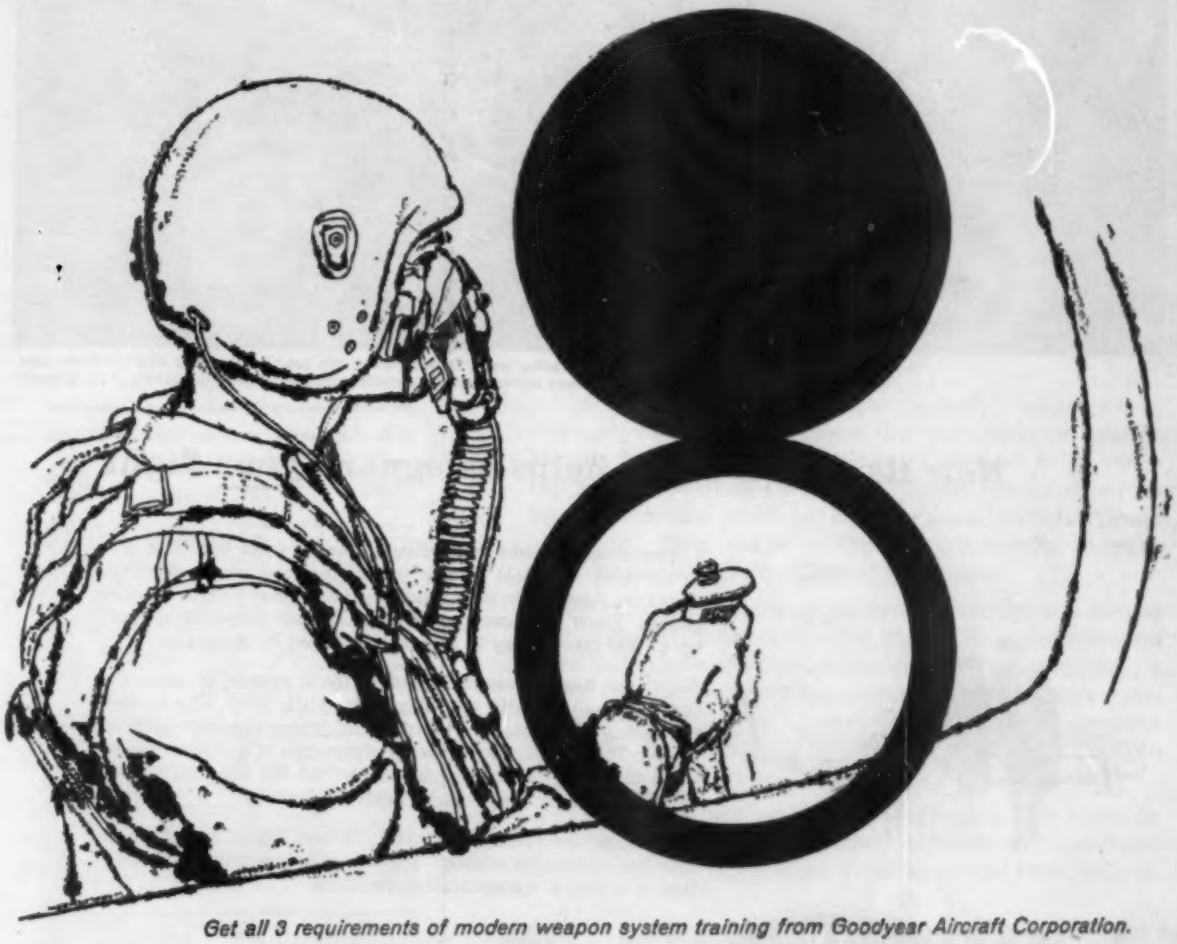

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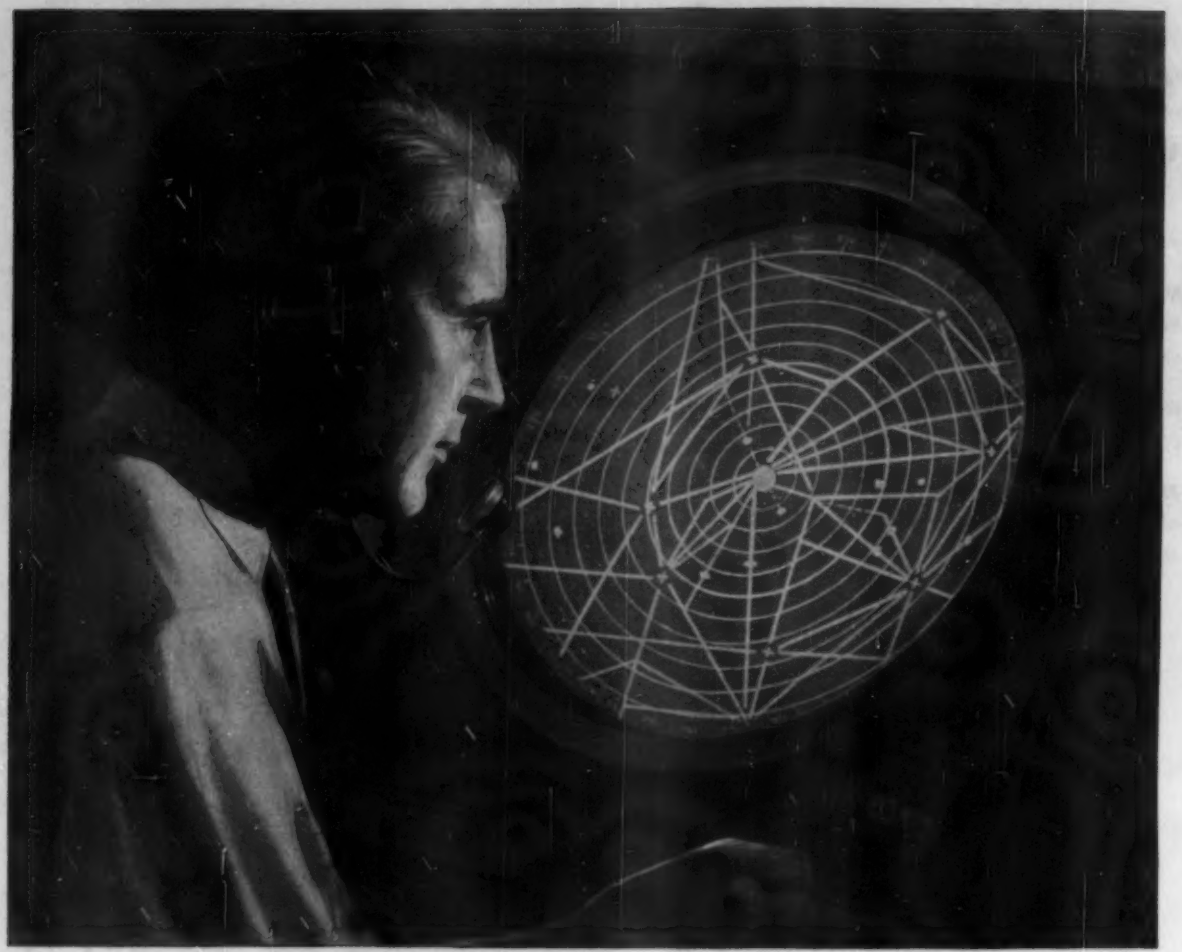

Raytheon Flight-Tracker radar, showing air routes near Indianapolis. Straight lines show routes, X's are check points, concentric circles indicate range in miles. "Pips" are aircraft.

New Raytheon radar helps safeguard your flight

Commercial, private and military flights total 69,000 a day in the U.S.! Control of this traffic, the task of the Federal Aviation Agency, is now aided by Raytheon Flight-Tracker radars. Each of these powerful units can pinpoint aircraft up to 200 miles away in all weather—even in storms.

Raytheon has delivered 26 radars for a system to span the continent—to be fully operational by Fall, 1959. The control network will eventually blanket the entire country with 70 radars. Plans also call for the incorporation of a unique microwave tube, the Raytheon *Amplitron*, in the Flight-Trackers to increase their range and tracking efficiency.

By helping the F.A.A. to control airways traffic, speed schedules and reduce "stacking," Raytheon brings nearer the solution of a major transportation problem.

Excellence in Electronics RAYTHEON **RAYTHEON MANUFACTURING COMPANY, Waltham, Mass.**

AVIATION CALENDAR

June 29-July 1—Third National Convention on Military Electronics, Sheraton-Park Hotel, Washington, D. C. Sponsor: Institute of Radio Engineers' Professional Group on Military Electronics.

July 16-17—Third biennial joint meeting, Radio Technical Commission for Aeronautics and Los Angeles Section of the Institute of Radio Engineers, Ambassador Hotel, Los Angeles, Calif.

July 20-21—Propellant Thermodynamics and Handling Conference, American Rocket Society's Propellants and Combustion Committee, Ohio Union, Ohio State University campus, Columbus, Ohio.

July 28-29—Quarterly Regional Meeting, Assn. of Local Transport Airlines, Westward Hotel, Anchorage, Alaska.

July 30-31—Quarterly Regional Meeting, Assn. of Local Transport Airlines, Fairbanks, Alaska.

July 30-31—Sixth Annual Symposium on Computers and Data Processing, Denver Research Institute, Stanley Hotel, Estes Park, Colo.

Aug. 4-5—Second Annual Western Regional Meeting, American Astronautical Society, Ambassador Hotel, Los Angeles, Calif.

Aug. 5-7—William Frederick Durand Centennial Conference on the problems of hypersonic and space flight, Stanford University, Stanford, Calif.

Aug. 12-14—Eighth Annual Conference on Applications of X-Ray Analysis, Stanley Hotel, Estes Park, Colo. Sponsor: Metallurgy Division, Denver Research Institute, University of Denver.

Aug. 17—First National Ultrasonics Symposium, Institute of Radio Engineers' Professional Group on Ultrasonics Engineering, Stanford University, Stanford, Calif.

Aug. 18-21—Western Electronic Show & Convention, Institute of Radio Engineers, Cow Palace, San Francisco, Calif.

(*Continued on page 6*)

AVIATION WEEK Including Space Technology

June 22, 1959
Vol. 70, No. 25

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Section of Doppler Receiver showing banks of Hycon Eastern Selective Doppler Amplifiers
Millstone Hill 84' Radar Antenna

The problems in long range radar for today's ballistic missile defense systems require solutions that are unique yet reliable. Meeting these criteria is the Lincoln Laboratory's "Millstone Hill System". Working closely with Lincoln Laboratory on the transient response problems, Hycon Eastern provided "comb set" crystal filters and associated circuitry forming complete networks termed Selective Doppler Amplifiers.

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Hycon Eastern is presently supplying crystal filter banks for airborne intercept, bomber defense, shipborne and land based detection and tracking systems. Write for Crystal Filter Bulletin.

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Washington, D. C., The LaSalle, Suite 815, 1028 Connecticut Ave., N.W., District 7-1575

AVIATION CALENDAR

(*Continued from page 5*)

Aug. 24-26—Gas Dynamics Symposium, American Rocket Society, Northwestern University, Evanston, Ill.

Aug. 24-26—Institute of the Aeronautical Sciences' National Specialists Meeting, a symposium on anti-submarine warfare, (classified), San Diego, Calif.

Aug. 27-28—International Commonwealth Spaceflight Symposium, Church House, Westminster, London, England.

Aug. 31-Sept. 2—Annual Army-Navy Instrumentation Program (ANIP) Symposium and Industry Briefing, Statler Hilton Hotel, Dallas, Tex.

Aug. 31-Sept. 5—10th Annual Congress, International Astronautical Federation, Church House, Westminster, London.

Sept. 1-2—Conference on physical chemistry in aerodynamic and space flight, University of Pennsylvania, Philadelphia, Pa. Sponsors: Air Force Office of Scientific Research and General Electric Co.'s Missile and Space Vehicle Dept.

Sept. 2-4—1959 Cryogenic Engineering Conference, University of California, Berkeley, Calif.

Sept. 3-6—National Convention and Aerospace Panorama, Air Force Assn., Exhibition Hall, Miami Beach, Fla.

Sept. 7-13—1959 Farnborough Flying Display and Exhibition, Society of British Aircraft Constructors, Farnborough, Eng.

Sept. 9-11—Sixth Midwestern Conference on Fluid and Solid Mechanics, University of Texas, Austin, Tex. Sponsors: AFOSR/Directorate of Aeronautical Sciences; Office of Naval Research; National Science Foundation.

Sept. 16-17—Western Regional Meeting on Frontiers on Science and Engineering, Institute of the Aeronautical Sciences, Los Angeles, Calif.

Sept. 20-25—14th Annual Conference and Exhibit, Instrument Society of America, Chicago Amphitheater, Chicago, Ill.

Sept. 21-22—Eighth Annual Meeting, Standards Engineering Society, on Investment in Survival, Somerset Hotel, Boston, Mass.

Sept. 23-24—Engine and Operations Symposium, Airwork Corp., Millville, N. J.

Sept. 24-25—Solid Propellants Conference, American Rocket Society, Princeton University, Princeton, N. J.

Sept. 28-30—1959 National Symposium on Telemetering, Civic Auditorium and Whitcomb Hotel, San Francisco, Calif. Sponsor: Institute of Radio Engineers' Professional Group on Space Electronics & Telemetry.

Oct. 5-7—Seventh Anglo-American Aeronautical Conference, Institute of the Aeronautical Sciences, Hotel Astor, New York.

Oct. 5-10—National Aeronautic Meeting, Society of Automotive Engineers, the Ambassador, Los Angeles, Calif.

Oct. 6-8—12th Annual Meeting, National Business Aircraft Assn., Hotel Leamington, Minneapolis, Minn.

Oct. 6-9—International Symposium on High Temperature Technology, Asilomar Conference Grounds, Monterey Peninsula, Calif. Sponsor: Stanford Research Institute.

Oct. 12-16—15th General Convention of the International Air Transport Assn., Tokyo, Japan.

Space age research gets a new headquarters—One of the largest and best-equipped research facilities in the nation is the new 16-million-dollar Avco Research Center at Wilmington, Massachusetts. Here, research and development in space age technology is already being conducted in areas ranging from missile re-entry to satellite design. From work such as this—and equally important work at the nearby Avco Research Laboratory—will come further contributions to national security and the conquest of space.

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CIRCLE NO. 7 READER SERVICE CARD 7

Why the Navy's new T2J jet trainer is so easy to maintain

Economy of operation was designed into the T2J. One basic concept—accessibility for fast servicing—has resulted in maximum simplicity in everything from preflight checks to major overhauls:

1. All major equipment components—including the engine—*outside* the basic fuselage structure.

2. Large, quick-opening doors for the fuselage bays, which swing up to give waist-level access to all major systems.

3. Quick, complete access to cockpit consoles and contained equipment.

4. Related consoles and systems on the same side of the fuselage to give short-run, easy-to-trace wiring.

5. Horizontal stabilizer, elevators, ailerons, and tabs interchangeable.

6. Service-proven, off-the-shelf components wherever possible.

It doesn't take long to service a T2J. Major system components, mounted on shelves in the equipment bays, can be changed in minutes. The engine can be removed in 7 minutes and replaced in 20, using a standard BuORD bomb dolly.

So the T2J is soon back on the flight line, ready for the job it was designed to do: producing better-trained operational pilots for the Navy at the minimum possible cost.

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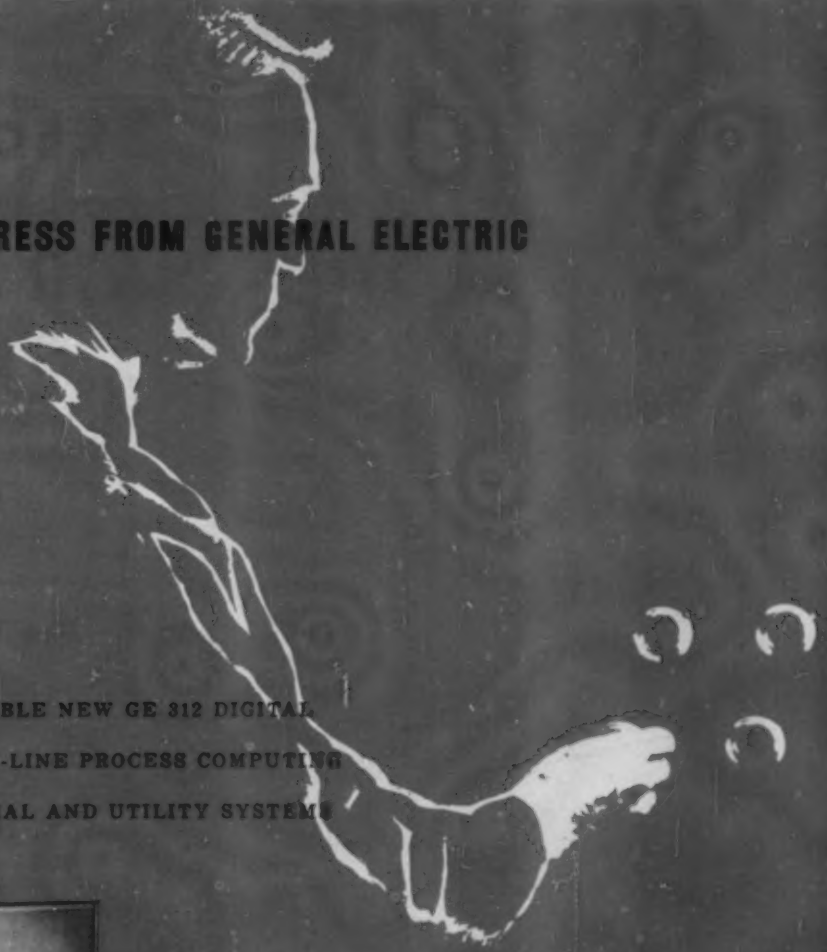

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Through the years Bell has earned top recognition for achievements in the development and production of advanced research aircraft.

Continuing this pioneer tradition, the Bell X-14 which rises and lands vertically in a conventional horizontal attitude has demonstrated that the minimum take-off requirements of helicopters can be combined successfully with high-speed jet performance. An operational military airplane embodying this Bell-pioneered VTOL concept is now in advanced stages of development.

Today, however, BELL means much more than AIRCRAFT!

In the field of *Space Flight,* Bell engineers are making many contributions to steady progress toward man's conquest of that incredible wilderness beyond the earth's atmosphere.

In *Avionics,* Bell has developed an all-weather automatic landing system which brings aircraft in to touchdown on land or carrier without pilot control. In tests it has landed the Boeing 707, the B-47 and Regulus II. Hipernas II, a new concept in advanced inertial navigation—and many other important systems, sub-systems and components also are under development.

In *Rocketry,* Bell accomplished the first large-scale rocket thrust chamber firing using the ultimate in chemical oxidizers, elemental liquid fluorine. Bell has also played an important role in the development and production of propulsion systems for many of our present arsenal of missiles, as well as Discoverer.

Bell's capabilities embrace not only research and development but efficient and economical production as well. Perhaps Bell can serve you. Your inquiry will receive prompt attention.

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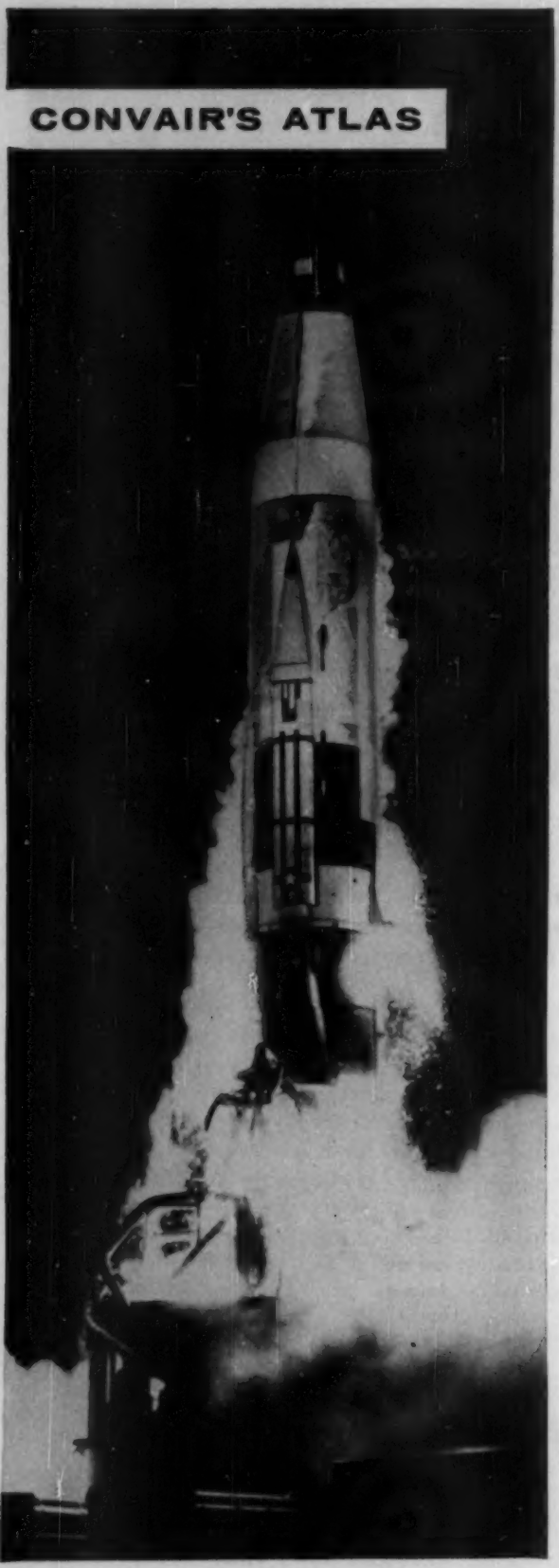

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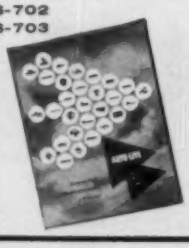

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Shown is the Talon T-38 trainer, developed in parallel with the new N-156F supersonic jet fighter by Norair, a division of the Northrop Corporation. When the N-156F comes off the production line, it will carry Chatham power supply 28VS100BL-1—a 100 amp, blast-cooled, silicon unit especially designed to Northrop specifications.

Chatham power supplies selected for NORTHROP space-age jet fighter!

Northrop, to secure the finest quality materials and components for its new N-156F supersonic counterair fighter, called on over 575 different manufacturers, each a specialist in a particular field. For power conversion equipment, Northrop chose Chatham.

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17 VENT RELIEF VALVE
Dwg. No. 31-1876-000
Vents fuel tanks during refueling and crossfeed.

18 PRESSURE RELIEF VALVE
Dwg. No. 34-2041-000
Provides precise pressure relief with minimum fuel or air pressure drop.

19 HIGH TEMPERATURE RELIEF VALVE
Dwg. No. 34-2109-000
Provides precise pressure relief with maintenance of constant pressure in combustion chamber.

20 PRESSURE RELIEF VALVE
Dwg. No. 34-2024-000
Prevents overpressurization of aircraft cabin air.

21 PRESSURE REGULATOR VALVE
Dwg. No. 46-2092-000
Provides constant line or tank pressure and prevents reverse flow from tank.

22 CONSTANT FLOW REGULATOR
Dwg. No. 39-1951-000
Provides precise constant flow rate under varying differential pressures with integral relief valve.

23 400 CYCLE AC OR DC SHUT-OFF VALVE
Dwg. No. 32-2102-000
Controls high temperature gas flow in ejection system.

24 IMPENDING BYPASS FLUID FILTER
Dwg. No. 52-2290-001
Provides audible or visible signal before filtering element becomes clogged.

25 HIGH PRESSURE RELIEF VALVE
Dwg. No. 33-2139-001
Prevents excessive pressure from damaging other components in engine fuel system.

26 400 CYCLE AC SOLENOID VALVE
Dwg. No. 31-2294-000
Provides fuel flow control under high temperature with unrectified AC solenoid operation.

27 INERTIA VALVE
Dwg. No. 35-2064-001
Prevents loss of fuel under high acceleration forces.

28 DRAG CHUTE CONTROL
Dwg. No. 11-2161-001
Provides precise control over release of landing parachute.

29 HYDRAULIC PACKAGE
Dwg. No. 64-2206-001
Provides locked positioning of missile launcher with high impact resistance.

30 FUEL FILTER WITH BYPASS
Dwg. No. 52-2134-001
Provides 74-Micron fuel filtration in airframe fuel system.

31 HOT GAS SHUT-OFF VALVE
Dwg. No. 33-2258-001
Controls flow of high temperature, high pressure products of combustion.

32 BUTTERFLY VALVE
Dwg. No. 31-1943-000
Provides positive shut-off with thermal relief.

33 COMPLETE CAPABILITIES REPORT

These bulletins represent only a partial list of our capabilities. May we suggest you discuss your specific problem with us . . . request our capabilities report.

AERO SUPPLY MFG. CO. INC.
CORRY, PENNSYLVANIA

electro-mechanical devices . . .
engineered fluid control systems . . .
precision manufacturing

AERO SUPPLY MFG. CO. INC.

Gentlemen: Please send me this technical data:

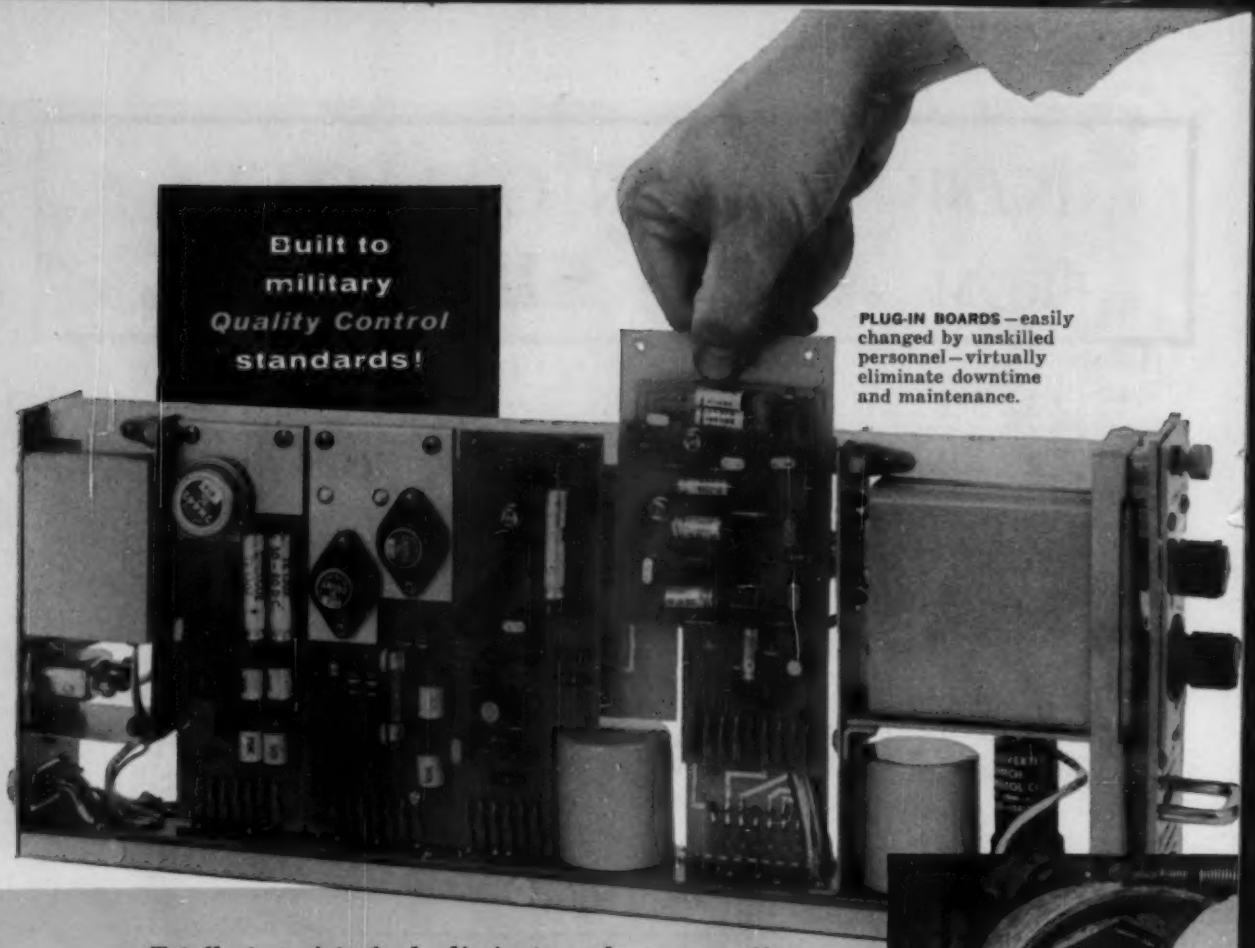
1 2 3 4 5 6 7 8 9 10 11
12 13 14 15 16 17 18 19 20 21 22
23 24 25 26 27 28 29 30 31 32 33

NAME & POSITION_____

COMPANY_____

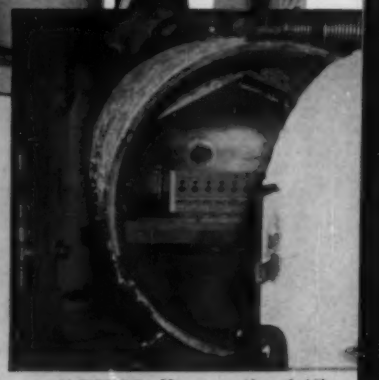
ADDRESS_____

_____



PLUG-IN BOARDS—easily changed by unskilled personnel—virtually eliminate downtime and maintenance.

Totally transistorized—dissipates only seven watts.
Drift less than 2 microvolts per 200 hours.
Single ended or differential input.
19" panel accommodates eight instruments.
DC to 50,000 cps.
Noise less than 10 microvolts wideband.
Operates to specifications from 0 to 50°C.
Self-contained power supply—operates on any line frequency from 50-400 cps.
Mil-type chopper gives unmatched reliability for the life of the instrument.



ALTITUDE—Non-operating A-12's were subjected to 1.6 psi (50,000') for one hour, and then operated at 6,000' and at sea level pressures.

SPECIFICATION SUMMARY – MODEL A-12

	Single Ended Input	Differential Input
Gain:	Fixed gain set to any value from 10 to 1000 inclusive by front panel plug-in units. Gain switching plug-in attenuator available with gains of 0, 10, 20, 50, 100, 200, 500 and 1000. Adjustable upward 2½ to 1 or more from setting with potentiometer.	Fixed gain set to any value from 10 to 1000 inclusive by front panel plug-in units. Gain switching plug-in attenuator available with gains of 0, 10, 20, 50, 100, 200, 500 and 1000. Adjustable upward 2½ to 1 or more from setting with potentiometer.
Input Impedance:	100 megohms shunted by 0.001 mfd (typical).	10,000 ohms.
Source Impedance:	5K maximum.	
Drift:	Less than 2 microvolts in 200 hours at constant ambient temperature. Less than 0.4 microvolt per degree centigrade.	Less than 4 microvolts in 200 hours at constant ambient temperature. Less than 0.8 microvolt per degree-centigrade.
Ambient Temperature:	0° to 50°C.	0° to 50°C.
Noise (Referred to input):	0-3 cps 5 microvolts peak to peak. 0-750 cps 5 microvolts rms. 0-50 kc 10 microvolts rms.	0-3 cps 10 microvolts peak to peak. 0-750 cps 7 microvolts rms. 0-50 kc 14 microvolts rms.
Frequency Response:	±3db to 50 kc (typical); ±1.0% to 2 kc.	±3db to 50 kc (typical); ±1.0% to 2 kc.
Output Capability:	±10 volts at ±100 ma DC or peak AC to 10 kc.	±10 volts at ±100 ma DC or peak AC to 10 kc.
Common Mode Rejection:		100db at DC; 72db at 60 cps for common mode voltage up to 50 volts DC or peak AC.

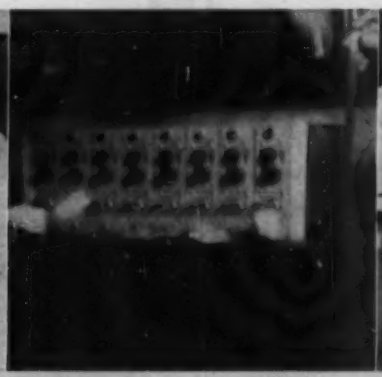
Only Electro Instruments DC Amplifiers meet rugged military environmental tests!

Totally-transistorized Model A-12's picked for ICBM Ground Support Equipment

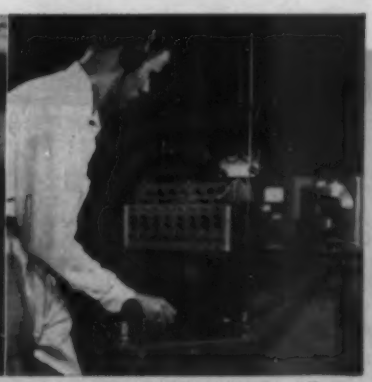
The photographs below were taken while eight Model A-12's were undergoing environmental qualification tests by independent MIL-approved laboratories.

PLUG-IN ATTENUATORS provide a choice of differential, single ended, or operational inputs for maximum operator convenience, flexibility and economy. Special variations, gain settings, etc., can be tailored to *your* system at no extra cost.

TEMPERATURE—The A-12's were operated at 50°C. ±2° for 12 hours and at 0°C. for 12 hours, and after storage at 70°C. and −40°C. for 24 hours.



SHOCK—The A-12's were subjected to 4" pivot drops and 1" free drops on all practicable faces for a total of five drops on each face.



ELECTRO INTERFERENCE—All tests conformed to RADC Exhibit 2313A.

The A-12 is certified as incorporating no fungus nutrient material!

Design and construction techniques of the Model A-12 Amplifier are fully *two years ahead of the field!* Totally transistorized circuits give the A-12 unmatched reliability and performance, and minimize heat dissipation problems inherent in vacuum tube instruments. Plug-in etched circuit boards and modular internal construction make servicing and maintenance checks easy—the amplifier can be disassembled and reassembled in less than 10 minutes. These advanced features enabled the Model A-12 to meet stiff military environmental qualification tests and resulted in their being selected for use in the ground support equipment of the nation's most advanced ICBM program.

Why not ask your E-I representative for the full story today?

SMALLEST PACKAGE EVER!
Eight Model A-12's can be mounted in standard 19" panel.

Electro Instruments, Inc.

3540 AERO COURT
SAN DIEGO 11, CALIFORNIA

CIRCLE NO. 19 READER SERVICE CARD

Philco Ground-Space Communications System commands and tracks **DISCOVERER** satellite

DISCOVERER . . . the United States' newest earth satellite . . . is opening new vistas on the frontier of outer space. And Philco is proud to play an important role in this renowned achievement as a part of the Discoverer Team . . . in conjunction with the Lockheed Aircraft Corporation and the Air Force at the direction of the Advanced Research Projects Agency of the Department of Defense.

As the subcontractor for Discoverer's entire communications system, Philco designed and developed the vast complexity of ground-space communications, tracking, commanding and data gathering and processing systems.

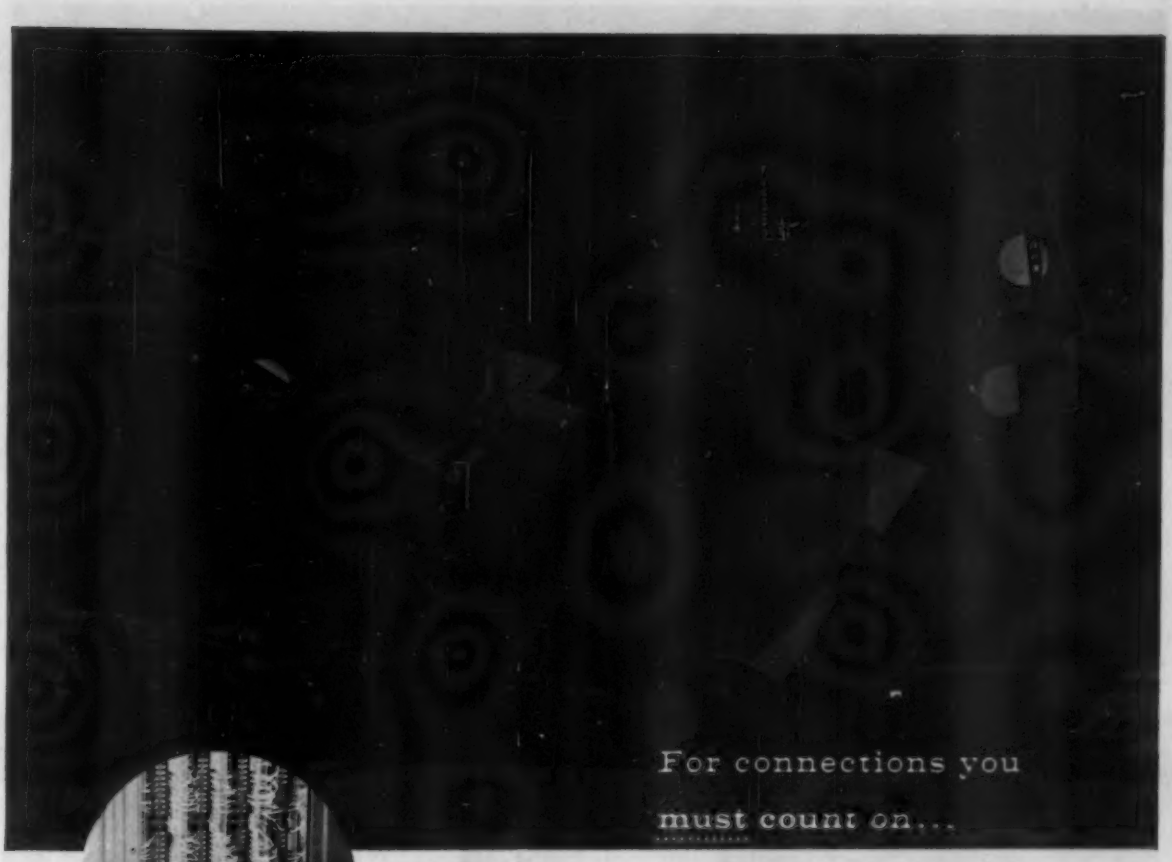
The Philco-designed and equipped system observes and commands Discoverer through a series of five tracking and data collection stations in Alaska, California, Hawaii and a specially equipped ship at sea. Philco continues its participation in the Discoverer Program by assisting in the actual operation and maintenance of the communications and data handling network.

Philco's part in the Discoverer Program is typical of the many and diverse advanced research and development activities being conducted in our laboratories on the East and West Coasts where outstanding career opportunities abound for Engineers, Mathematicians, and Physicists.

In the wonder-world of advanced electronics, look to the leader. Look ahead . . . and you'll choose Philco!

PHILCO®

GOVERNMENT AND INDUSTRIAL DIVISION
WESTERN DEVELOPMENT LABORATORIES
PHILADELPHIA, PENNSYLVANIA PALO ALTO, CALIFORNIA



be sure, be safe with

TWIN LOCK TERMINAL BLOCKS

Twin Lock terminal blocks offer the ultimate in terminal reliability, speed of assembly, and versatility of application. Molded of a lightweight phenolic base with reinforced barriers between cavities, the Twin Lock block will accommodate up to 40 connections quickly and surely. Twin Lock's exclusive, insert-and-tighten two-way locking action cuts harness assembly time to a fraction of that required by any other block. Twin Lock contact points, either tin plated, gold plated or plated to customer specification, assure lowest resistance connection. Wire end connectors, compatibly plated, can be supplied for manual or automatic assembly. Available in either vertical or side entry types, the Twin Lock block is applicable wherever a fast, positive, reliable electrical connection is required. For complete information on these remarkable new blocks, write for the T-1000 and T-1010 Terminal Block Brochure.

SIMPLE
The terminal connector, crimped onto the wire end, slips easily into the block cavity. No screws or washers to remove, nothing to drop, just insert it.

SPEEDY
When connectors have been inserted, they're locked electrically and mechanically. Then, when the circuits have been checked, a few quick turns of the lock screw and they're double-locked.

SURE
When the connector has been inserted and tightened, the Twin Lock terminal block connection is positive—electrically and mechanically. Over 100 lbs. force is required to break this connection.

TWIN LOCK INCORPORATED

1024 West Hillcrest Blvd.
Inglewood, California

Coliseum Tower, 10 Columbus Circle,
New York 19, New York

the highest,
the coldest,
the hottest
. . . IN THE SMALLEST *SPACE!*

Tenney-mite STRAT
environmental chamber

Altitudes to 200,000 ft., temperatures from –100° F to +350° F, in only 4 square feet of floor space. Now, any company can own a combined altitude and temperature test chamber . . . without sacrificing much valuable floor space. And the investment, too, is reasonable.

Only Tenney Engineering, world's largest and most experienced creator of environmental equipment, could produce the Tenney-mite Strat. Write for further information.

Write for a descriptive catalog and complete information on Tenney's research and development, engineering consultation, and design services.

Tenney ENGINEERING, INC.

OLDEST AND LARGEST MANUFACTURER OF ENVIRONMENTAL EQUIPMENT

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22 CIRCLE NO. 22 READER SERVICE CARD

GPL data handling

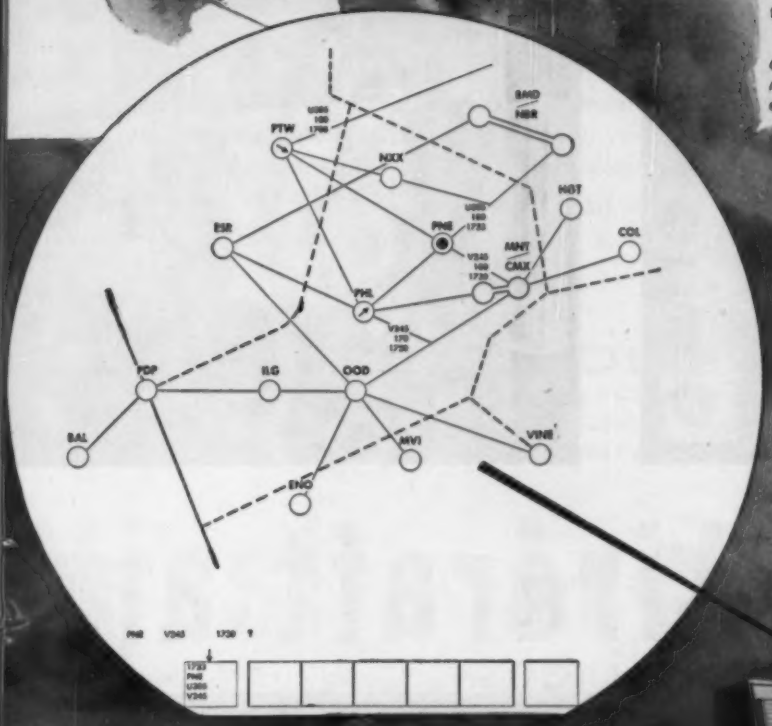
equipment for the Federal Aviation Agency

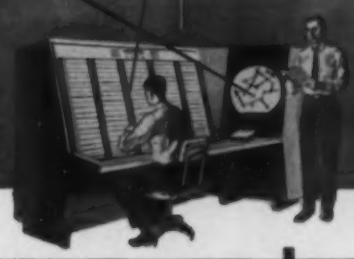
GPL's experience and ingenuity are at work assisting the FAA Bureau of Research and Development in the creation of a modern data processing central, the heart of tomorrow's air traffic control system. The central will receive up to 400 aircraft flight plans hourly, "remember" 1,000 such plans simultaneously and transmit 200 plans and 800 updates hourly to adjacent centers. Automatic processing and unique displays of such data will make significant contributions to the efficient control of aircraft in en-route, transition and terminal areas.

The FAA data processing central is just one of a number of airborne and ground-based programs reflecting GPL's capabilities in the data handling field. These programs are supported by GPL's proven ability to understand the customer's problem and capacity to anticipate future requirements. The GPL organization is "systems oriented," offers complete capabilities ranging from research, engineering and manufacturing to customer service.

Why not put these broad capabilities to work on your problem?

GPL Avionic Division/airborne navigators/missile guidance/radar/airborne computers/data handling systems/communications equipment/infra-red/closed-circuit TV.





ENGINEERS — GPL achievements have opened up some unusual research and development opportunities. Send resume to Personnel Director.

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GPL

A GENERAL PRECISION COMPANY

GENERAL PRECISION LABORATORY INCORPORATED, Pleasantville, N. Y.

A Subsidiary of General Precision Equipment Corporation

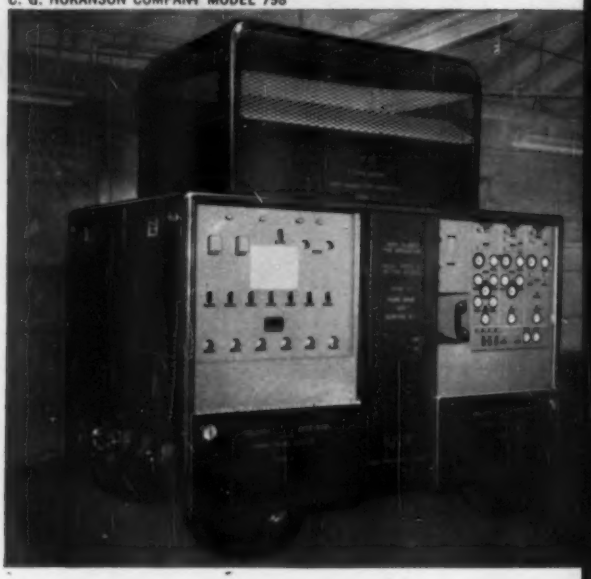
CIRCLE NO. 23 READER SERVICE CARD 23

SOLAR T-41M-9

AMERICAN AIR FILTER CO. DEFENSE PRODUCTS DIVISION C-10

STRATOS DIVISION-FAIRCHILD ENGINE & AIRPLANE CORP. GEA 120-1

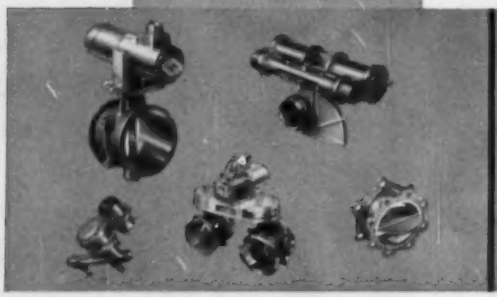
C. G. HOKANSON COMPANY MODEL 798

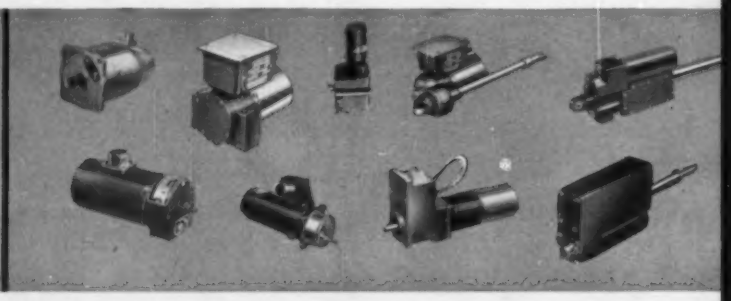


THE MARK OF QUALITY

BARBER COLMAN

Aircraft and





AIR VALVES — A wide variety of electrically and pneumatically operated air valves for temperature and pressure-control applications. Butterfly, check, poppet, slide, and automatic drain types.

ACTUATORS — Rotary and linear types featuring a wide range of gear reductions switching and mounting details. Available either as standard units or special designs to fit various applications. Designed to applicable military specifications.

Barber-Colman ground support temperature controls chosen by leading makers of ground carts and auxiliary power units

Today's highly advanced air and space vehicles call for an ever-increasing array of support equipment — either as preflight air conditioning units or in-flight auxiliary power sources. On many of these, such as shown here, Barber-Colman temperature control systems are employed.

For these systems, components such as control boxes, actuators, valves, temperature sensing elements, thermostats — are furnished by Barber-Colman Company. The systems are specifically engineered for each application by engineers of the unit manufacturer and Barber-Colman.

Typical functions of Barber-Colman controls in ground support units include controlling temperature of missile guidance compartments and shrouds . . . controlling temperature of missile measurements compartments . . . controlling preflight cabin temperature of jet tankers . . . and many similar precision applications.

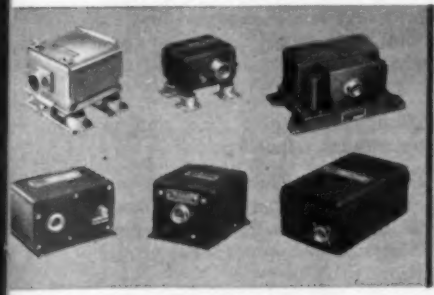
For help on your ground support control projects, consult the Barber-Colman engineering sales office nearest you: Los Angeles, Seattle, Ft. Worth, New York, Boston, Baltimore, Rockford, Montreal.

BARBER-COLMAN COMPANY

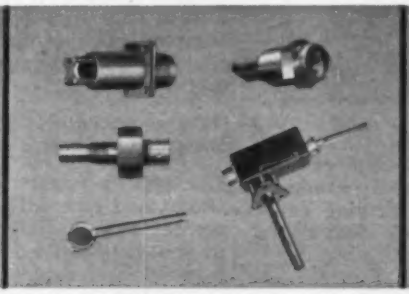
Dept. R, 1422 Rock St., Rockford, Illinois

Aircraft Controls • Electrical Components • Small Motors • Automatic Controls • Industrial Instruments • Air Distribution Products • Overdoors and Operators • Molded Products • Metal Cutting Tools • Machine Tools • Textile Machinery

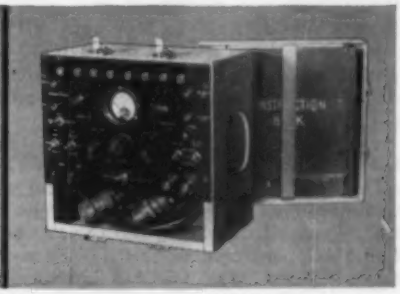
Missile Accessories



TEMPERATURE CONTROL AND POSITIONING SYSTEMS — Electronic, magnetic amplifier, transistor, or relay-controlled systems designed to meet your requirements.

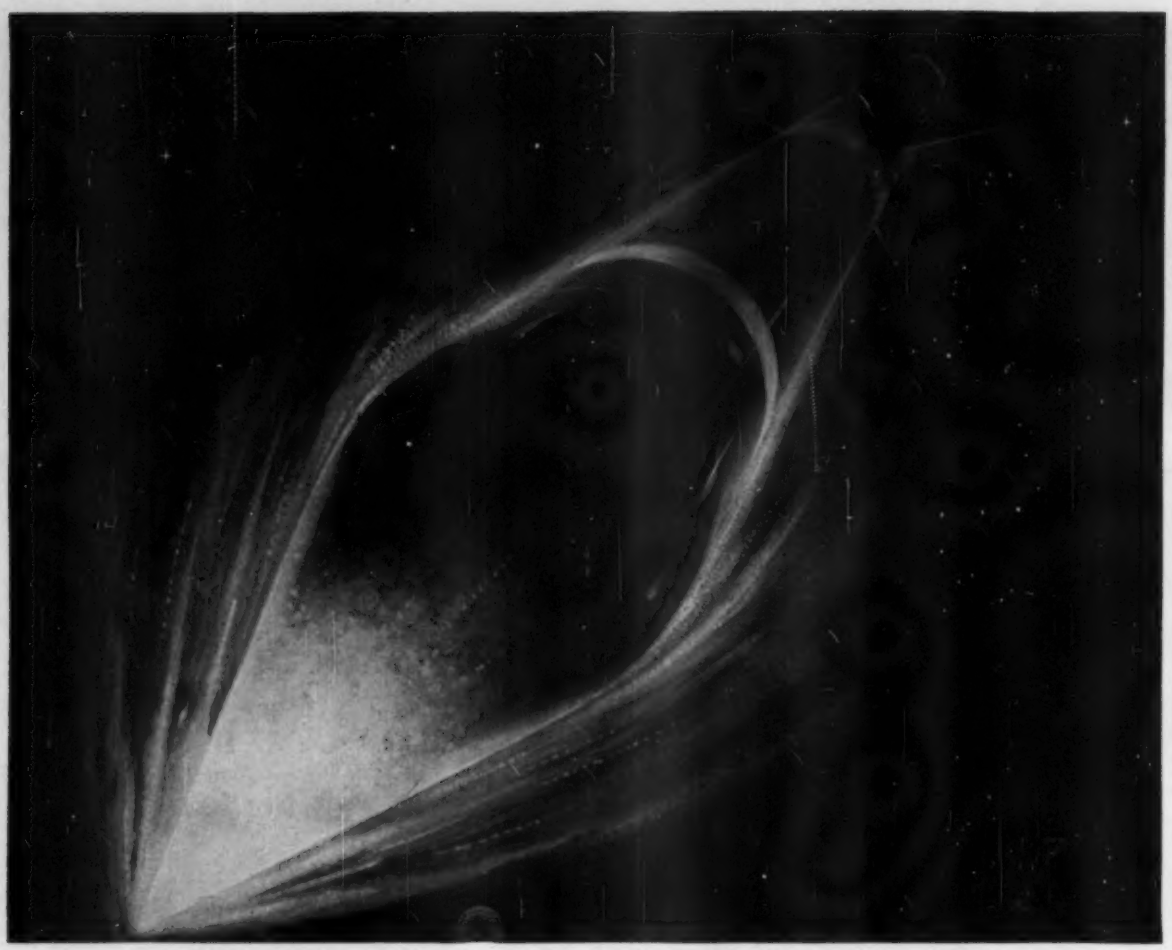


TRANSDUCERS AND THERMOSTATS — Units for sensing compartment, duct, windshield temperatures. CEDAC system senses, controls temperature and/or airflow in ducts.



TEST EQUIPMENT — Compact electrical test units for quickly checking all components of a Barber-Colman control system installed in an aircraft. Special units for checking many electrical systems.

CIRCLE NO. 25 READER SERVICE CARD 25



Sustained operating temperatures up to 400° F, as in guided missiles, are death to inferior electrical insulations and laminates. CDF glass-base laminates of Teflon*—the only laminates of their kind approved by the military—can take this punishment steadily.

LATEST HIGH-HEAT INSULATION SYSTEMS NEED CDF GLASS-BASE LAMINATES AND TAPES

Widest available range offers Teflon, epoxy, silicone, mica products for dimensional stability under continuous heat

As components and equipment grow smaller, and heat becomes more difficult to dissipate, CDF high-heat electrical insulations become increasingly important to electronic design. For nowhere else can such a wide range of quality insulations be found under one roof as at CDF.

FOR HIGH-HEAT PRINTED CIRCUITRY, CDF glass-base Di-Clad® laminates of Teflon* and epoxy exhibit best dimensional stability and current-carrying capacity. Constant operating temperatures of 300° F—soldering temperatures to 500°F—are readily met by these specialized CDF Di-Clad laminates.

HIGH-HEAT FLEXIBLE INSULATIONS. CDF offers a wide choice of insulating tapes made of Teflon, silicone varnish, silicone rubber, and Micabond®, with glass-cloth support. CDF tapes may be used either by hand wrapping or on automatic winding machines. Unsupported Teflon in colors available to meet MIL-STD 104.

TEFLON SPAGHETTI TUBING AND OTHER SPECIALTIES. Part of CDF's vast fabrication facilities is devoted to the production of custom parts from Teflon — spaghetti tubing, rods, sheets, and machined parts to rigid specifications.

NEW — *cementable* Teflon, bondable to itself and to other materials with commercial adhesives.

SEE SWEET'S Product Design File, Electronics Buyers' Guide, and other directories for the name and phone number of your CDF sales engineer. Then send your print or your problem, and we'll recommend the proper material for the application.

*trademark of DuPont tetrafluoroethylene resin

CONTINENTAL-DIAMOND FIBRE

A SUBSIDIARY OF THE Bird COMPANY • NEWARK 20, DEL.

DETREX Offers You PERM-A-CLOR, Plus Industry's Most Experienced Engineering Service

Solvent degreasing is a most economical method of metal cleaning. And DETREX PERM-A-CLOR is a premium grade trichlorethylene product—outstanding in stability, cleaning ability and solvent mileage. But PERM-A-CLOR is only part of the DETREX story.

Add DETREX's engineering organization—the most thoroughly trained men in this field—and you have another important reason why PERM-A-CLOR users get the most for their solvent dollar.

These experienced technicians stand ready to analyze your degreasing operation, and suggest procedures that in many instances reduce solvent consumption by a substantial amount. Put these experts to work for you today.

Depend on DETREX for Every Metal Cleaning and Processing Need

- PERM-A-CLOR NA (Trichlorethylene)
- Solvent Degreasers
- Ultrasonic Equipment
- Industrial Washers
- Phosphate Coating Compounds
- PAINTBOND Compounds
- Aluminum Treating Compounds
- Alkali and Emulsion Cleaners
- Rust Proofing Materials
- Extrusion and Drawing Compounds
- Spray Booth Compounds

Dr. W. L. McCracken has written a most interesting paper—"The Truth About Solvent Degreasing". Send for your free copy.

DETREX CHEMICAL INDUSTRIES, INC.

Box 501, Dept. AW-659, Detroit 32, Michigan

World's Largest Exclusive Producer of Cleaning Chemicals and Equipment

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Products	Types and Salient Features	Ratings
SYSTEMS Single Source Responsibility Coordinated Component Design		
a-c and d-c electric power systems	brushless generators, static exciters, control panels and regulators.	a-c up to 160 kva. d-c up to 750 amps.
variable-speed constant-frequency systems	(same as above)	VSCF up to 120 kva.
actuator systems	linear and rotary—electric, hydraulic, pneumatic and mechanical. Feedback control features. Integrated sensing and control devices.	to spec.
COMPONENTS		
actuators and geared drives	electric, hydraulic, pneumatic and mechanical. Lightweight, high temperature.	to spec.
a-c and d-c motors	"flexible standard" building block design permits completely customized motor for rapid delivery. Also SECSYN* brushless design for a-c requirements.	up to 20 hp in SAE Frames IV, V and VI. Also special configuration and ratings to specs.
engine starters	lightweight, high performance	up to 30 hp.
starter-generators	a-c and d-c. Compact, lightweight, high efficiency. Self-cooled and blast-cooled.	up to 750 amps d-c for engines rated to 4000-lb thrust or equivalent hp.
solenoids	a-c and d-c. High temperature.	to spec.
a-c tach and synchronizing generators	lightweight. Ambients to 750F.	to spec.
inverters	rotating and static designs. Static—transistor or controlled rectifier. Rotary—with static controls.	up to 3000 va.
relay networks	a-c and d-c for voltage, frequency, current and fault sensing.	to spec.
transformers, current	special low-power sensing and std. high-power sensing units. Lightweight L-P sensor ideal for differential protection, real load division and unbalanced current relaying.	to spec.
circuit breakers	a-c. Phase barriers throughout; balanced rotary latch; direct solenoid-actuated contacts; non-critical adjustment of interlocks.	to spec.
transformers, power	single and three-phase. High temperature.	to spec.
control panels	a-c and d-c. Customed to provide all protective and control functions specified. Printed circuits, static components and encapsulation.	matched to system requirements.
regulators and static exciters	transistor, controlled rectifier, mag-amp or carbon-pile. Average or Hi-Phase® sensing.	matched to system requirements.
generators, a-c	all contemporary generator types plus SECSYN* brushless and variable-speed constant-frequency (VSCF) design.	up to 160 kva. VSCF to 120 kva.
generators, d-c	all contemporary generator types plus SECSYN* brushless. High temperature and high speed.	up to 750 amps.

*Stationary-Exciter-Coil SYNchronous machines. Brushless, lightweight, extremely reliable design used as generator or motor.

Today's answer to your problem lies within these more than 400 proved J&H designs

J & H offers the most complete range of electric power systems and components available from a single source. Hardware developed, produced and placed into service over the past twenty years represents the conventional and the most sophisticated . . . and application is across the spectrum of aeronautics and astronautics:

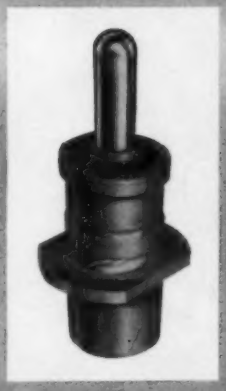
1 missiles of all classifications
2 missile ground support systems
3 manned military aircraft of all types
4 aircraft GPUs and APUs
5 commercial aircraft
6 personal and utility aircraft

JACK & HEINTZ, Inc.
SYSTEMS FOR AIRCRAFT, MISSILES, GROUND SUPPORT

For detailed information on the systems and components outlined at the left, write to Jack & Heintz, Inc., 17635 Broadway, Cleveland 1, Ohio.

BUFFER ABSORBS 23,200 FT.-LBS. IN 3.5" STROKE

WESTERN DESIGN buffers will stand by to protect men and missile on the Talos shipboard launcher. Eight of these hydraulic assemblies, all designed and produced by Western Design, are used throughout the hoistway.



WESTERN DESIGN is skilled and experienced in producing powerful energy absorbing devices complete from design through test. This specialized background in heavy ground and sea handling equipment, and more than 250,000 square feet of facilities are available to you for your system, assembly or component. *Call or wire for further details and 28-page brochure.*

USI Western Design

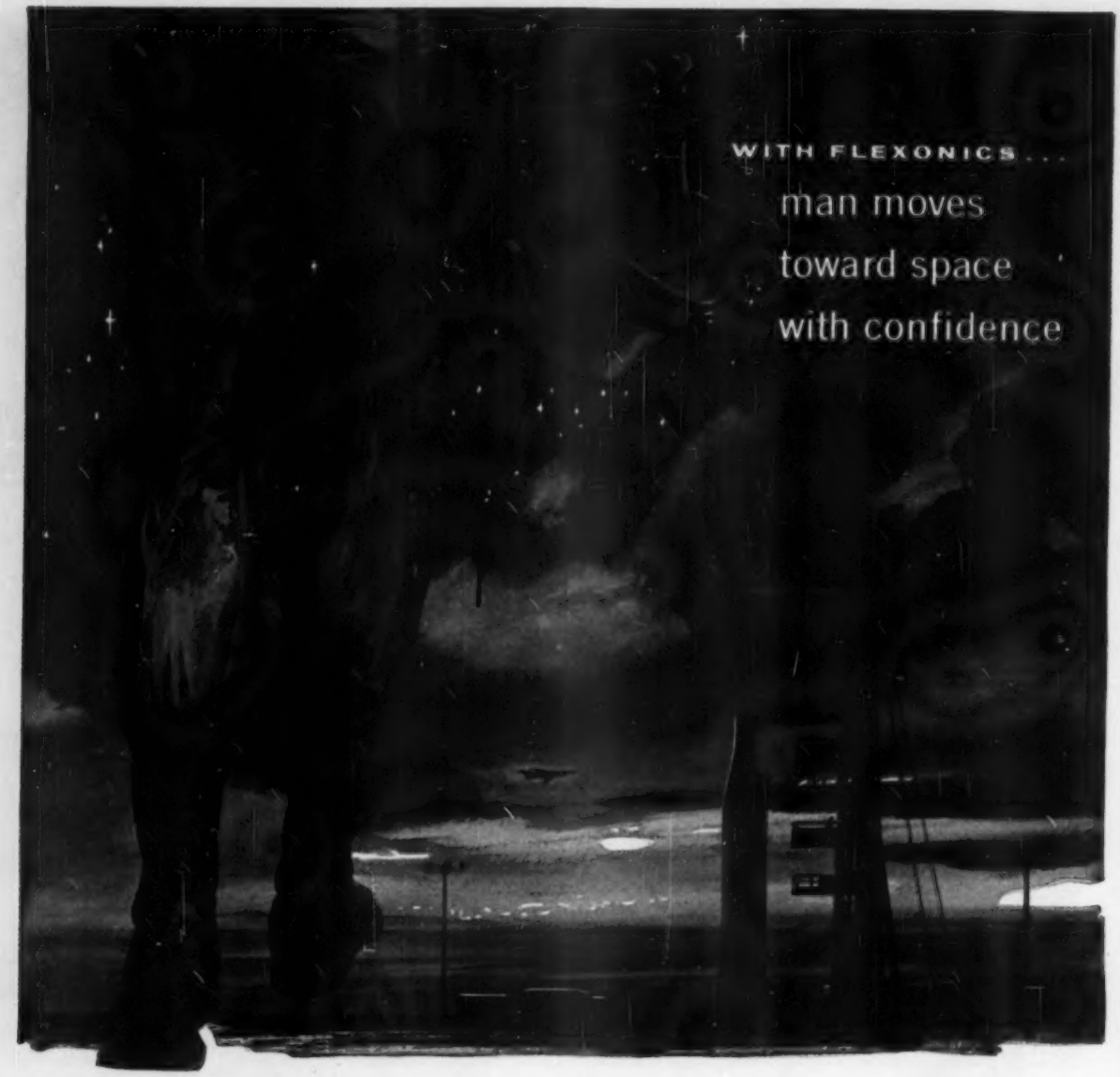
DIVISION OF U. S. INDUSTRIES, INC.

SANTA BARBARA AND MONTEBELLO, CALIFORNIA

7701 Telegraph Road • Montebello, California • RAymond 3-2611

WD-25-59

WESTERN DESIGN OFFERS PROVED PERFORMANCE AND RELIABILITY in the engineering and production of complete instrumentation systems, support equipment, electro-mechanical and rotary devices, flyaway cargo hoists, training systems, simulators, teaching machines and materials, ASW systems and components, hydraulic fluid systems, landing gear, and heavy ground and shipboard handling equipment.



When man first steps into the vehicle that will carry him into outer space, it will be with complete confidence.

He knows that he can rely on the extensive testing and preparations that have gone before. Flexonics has played a vital part in these preparations—engineering, designing, and manufacturing metal and synthetic components and systems for hydraulic, pneumatic, liquid oxygen, and fuel applications on America's best-proved missiles and aircraft.

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A-419

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AERONAUTICAL DIVISION

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In Canada: Flexonics Corporation of Canada, Limited, Brampton, Ontario

Why the Atlas...has an 18-8 Stainless skin

This skin runs hot and cold. Cold because of liquid oxygen down at –297°F. And hot because of aerodynamic heating which may heat it to the 400 to 600°F range.

The problem was to get a material which is strong in thin gauges of sheet, yet keeps its strength, toughness and ductility at extremely low temperatures . . . as well as moderately elevated ones. Of course, it must resist oxidation and many atmospheric environments, too.

Designers at General Dynamics-Convair Division found that the 18-8 Austenitic Stainless Steels, which contain about 8% Nickel, have excellent low temperature properties and meet all of the other requirements as well. In addition, 18-8 Stainless Steels can be formed and welded readily.

Easily fabricated 18-8 Stainless Steels could be your answer to a sub-zero problem. If you'd like information on their low temperature properties, it's yours for the asking from Inco.

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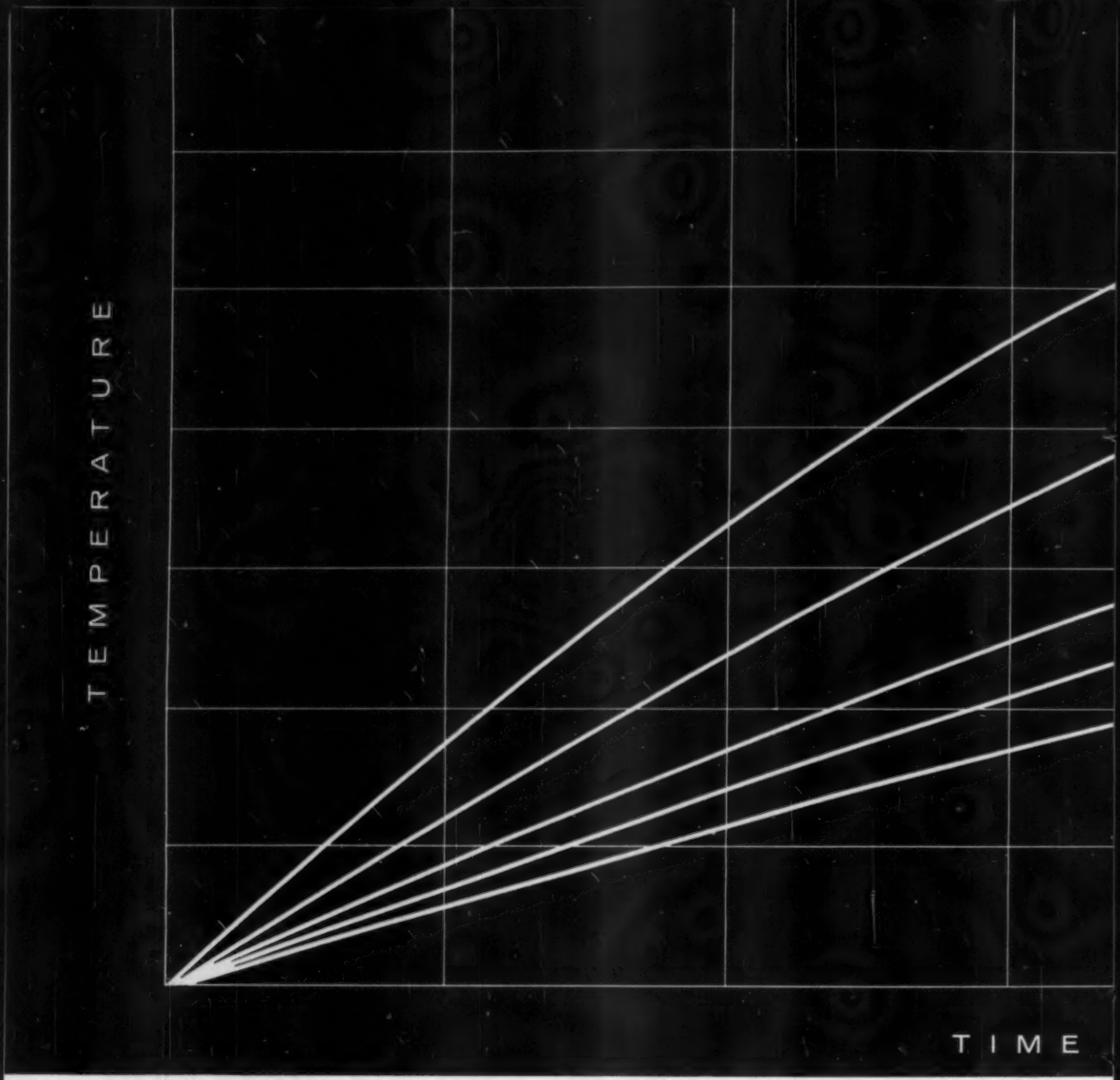


from Westinghouse...system coordinated

Westinghouse energy storage systems are guaranteed-compatible to insure proper temperature/time conditions so essential to accurate missile evaluation.

Using typical circuits like the one shown, Westinghouse analog and digital computers make thousands of calculations to determine precisely the electrical apparatus required to provide proper air flow environments for missile testing. Capacitor energy levels, conductor spacing, collector sizing and hundreds of other factors are weighed and balanced so that over-all system impedance yields the optimum energy transfer for a given time.

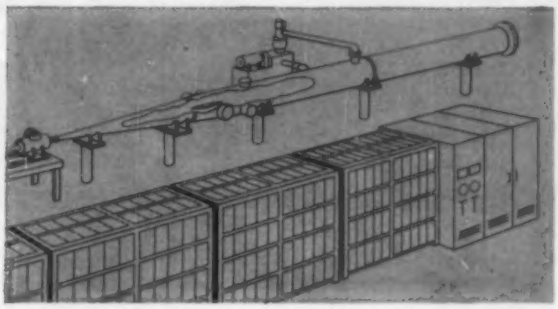
With these pre-assembly calculations, design engineers select, from the wide range of Westinghouse apparatus, components to blend properly for the most reliable and economical system: Precise repeatability of test conditions, another important factor in all missile testing, is assured by the quality and compatibility of the individual components.

Whether your program requires a capacitive or inductive system, take advantage of this Westinghouse single-source guaranteed-compatibility of apparatus to be sure that your Hotshot facility will have the best energy storage system. Contact your Westinghouse sales engineer or write: Westinghouse Electric Corporation, 3 Gateway Center, P.O. Box 868, Pittsburgh 30, Pennsylvania.

J-92032

electrical equipment for Hotshot facilities

A representative Westinghouse capacitive storage system includes: fused capacitor units, packaged charger, controls and coaxial conductor system. Advantages of the capacitive system are: maximum flexibility of power level; easily expanded capacity; 30-second (or less) cycling; long life; lower initial cost; no excessive power demand for system operation.



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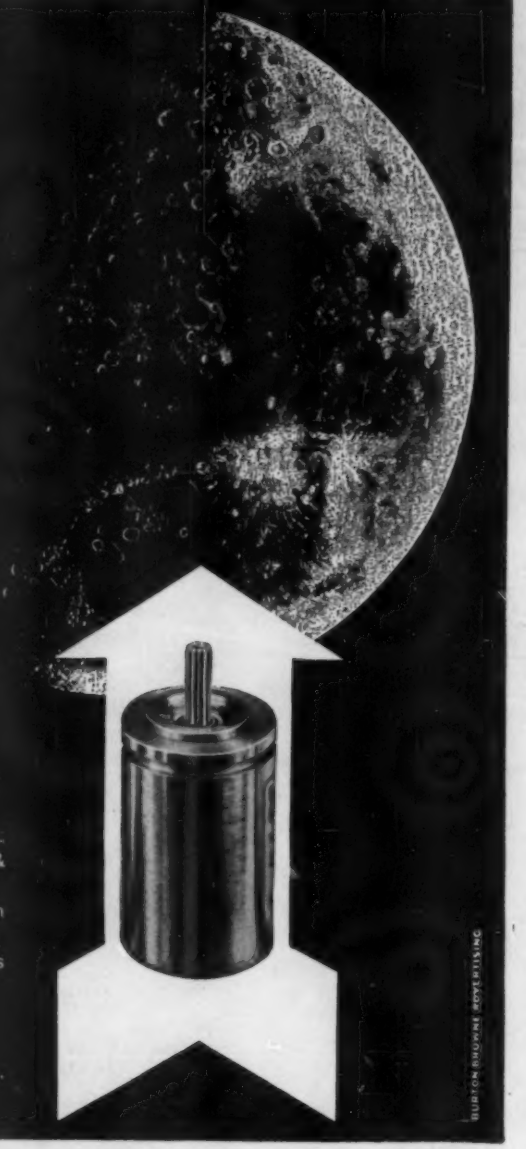

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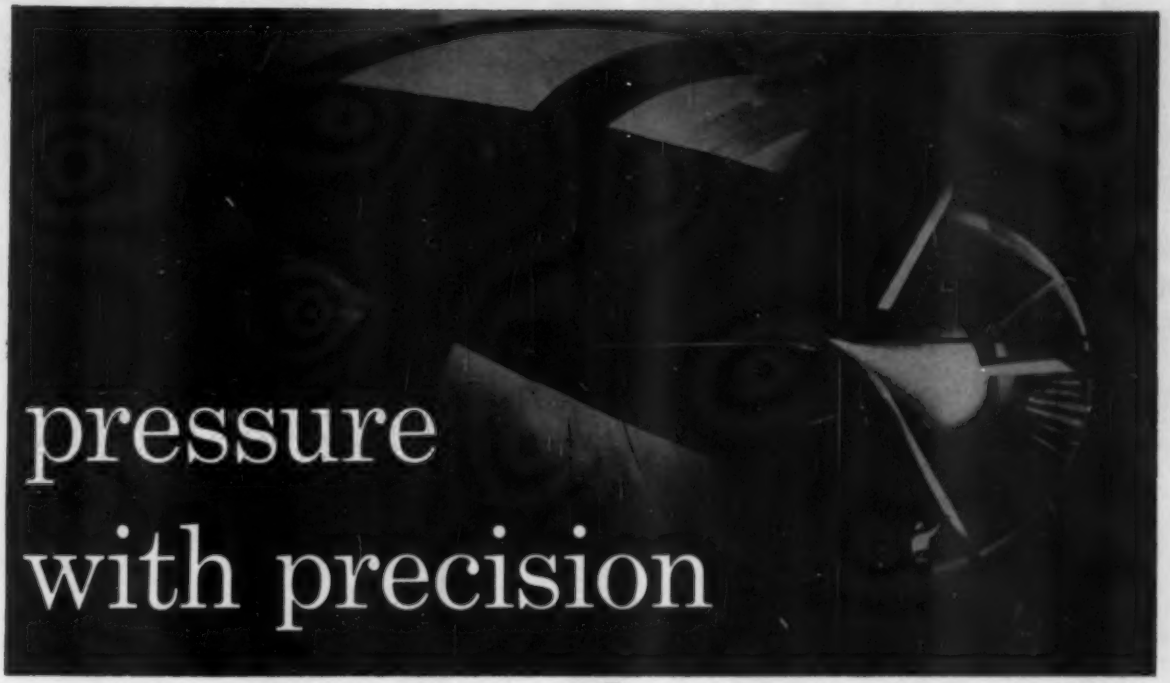
Engineers For Advanced Projects: Interesting, varied work on designing transistor circuits and servo mechanisms. Contact Mr. Robert Burns, Personnel Manager, in confidence.



pressure with precision

When critical pressures must be delivered or measured, Consolidated Systems are on the job, surpassing design specifications. Digital pressure measurement for windtunnels, automatic calibration of pressure transducers, missile propellant systems checkout with accuracies of one part in 2,000... these are being accomplished day-in and day-out, with precise pressures delivered at the turn of a dial. This type of performance is available for your application. Write for the complete story in Bulletin 3018-X4.

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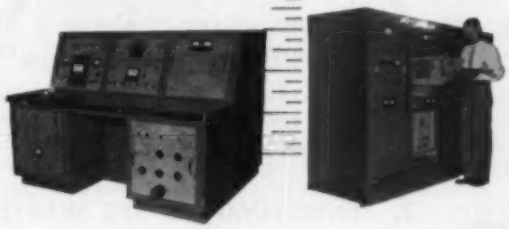

Propellant Utilization System Exerciser checks missile system performance by generating precise pressures for fuel and oxidizer channels at preselected points. Twenty-one similar systems are now in use at missile test sites.

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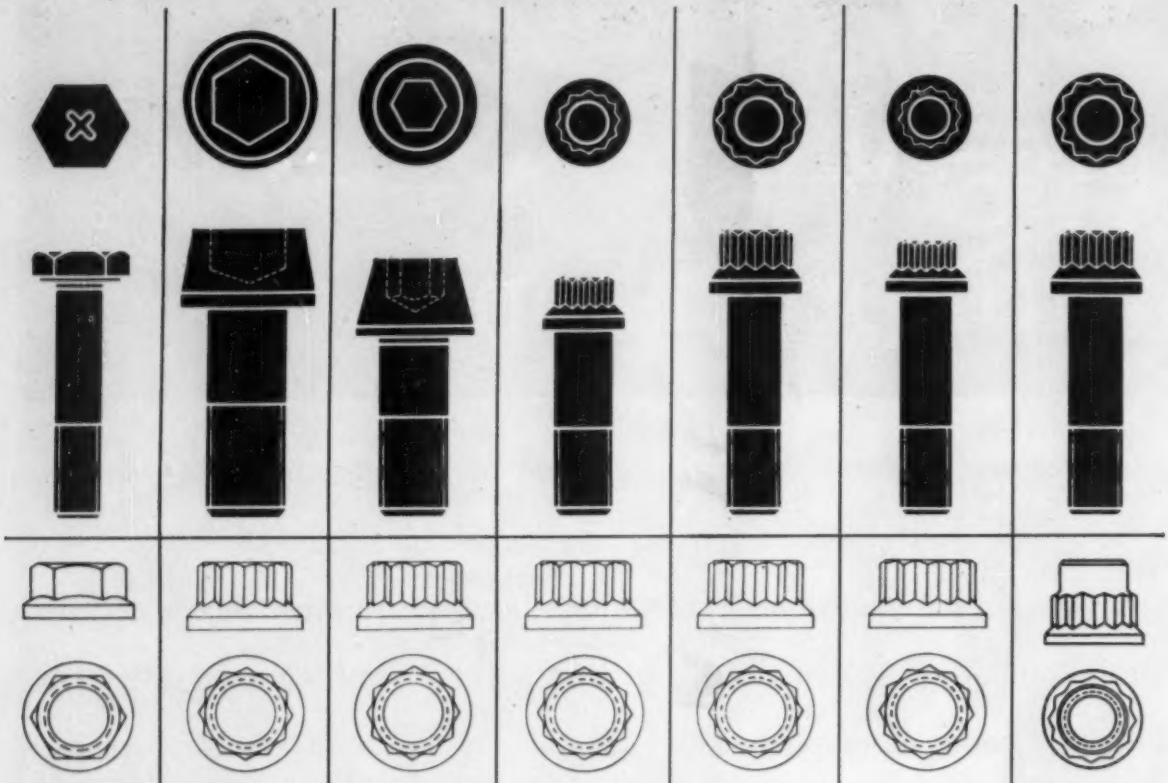
SPS RELIABILITY | *A dynamic standard of predictable performance*

Just name the tensile strength . . .

SPS offers a tension bolt and companion locknut for every application up to 260,000 psi



125,000 psi	160,000 psi	180,000 psi	180,000 psi	220,000 psi*	220,000 psi†	260,000 psi
AN 3 hex head external wrenching bolt and SPS FN-12 Featherweight hex locknut. Sizes #4 through 1 in.	NAS 144 internal wrenching bolt and SPS FN-18 Featherweight 12-point external wrenching locknut. Sizes ¼ through 1½ in.	(high fatigue strength) MS 20004 internal wrenching bolt and SPS FN-18 Featherweight 12-point external wrenching locknut. Sizes ¼ through 1½ in.	NAS 624 12-point external wrenching bolt and SPS FN-18 Featherweight 12-point external wrenching locknut. Sizes ¼ through 1½ in.	SPS Hi Psi EWB-22 12-point external wrenching bolt and SPS FN-22 Featherweight 12-point external wrenching locknut. Sizes #10 through 1½ in.	SPS Hi Psi LWB-22 12-point external wrenching bolt provides 220,000 psi muscles in a 180,000 body. Weight savings up to 32% when used with SPS FN-22. Sizes #10 through 1½ in.	SPS Hi Psi EWB-26 12-point external wrenching bolt and SPS FN-26 Featherweight 12-point external wrenching locknut. Sizes #10 through ⅞ in.

*Designed for use in 2024T4 aluminum. †Lightweight configuration for use in 7075T6 aluminum or harder materials.

Tension bolts and locknuts shown (a fraction of the complete SPS line) are serviceable to 550°F. Other combinations are available for service through 1600°F. Whatever your particular need, SPS can offer a performance-matched bolt and locknut assuring a joint of highly predictable performance. For further information, write SPS—manufacturer of precision threaded fasteners and allied products in many metals, including titanium.

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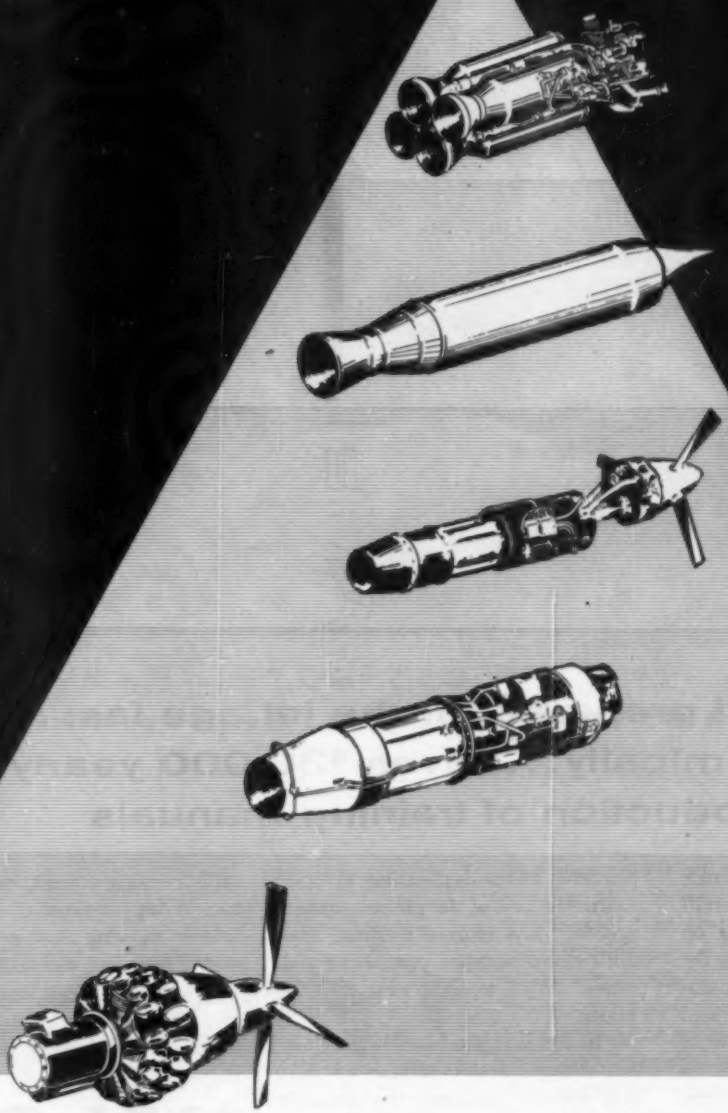

Bendix* has long been a leader in supplying controls and fuel systems for all types of aircraft engines. Today, Bendix is proving to be a natural for new challenges in related missile fields—on ram jets, rockets, nuclear power, and other advanced propulsion systems. So, when it comes to controls, remember that Bendix has the background—and is anxious to share it in solving your problems. *REG. U.S. PAT. OFF.

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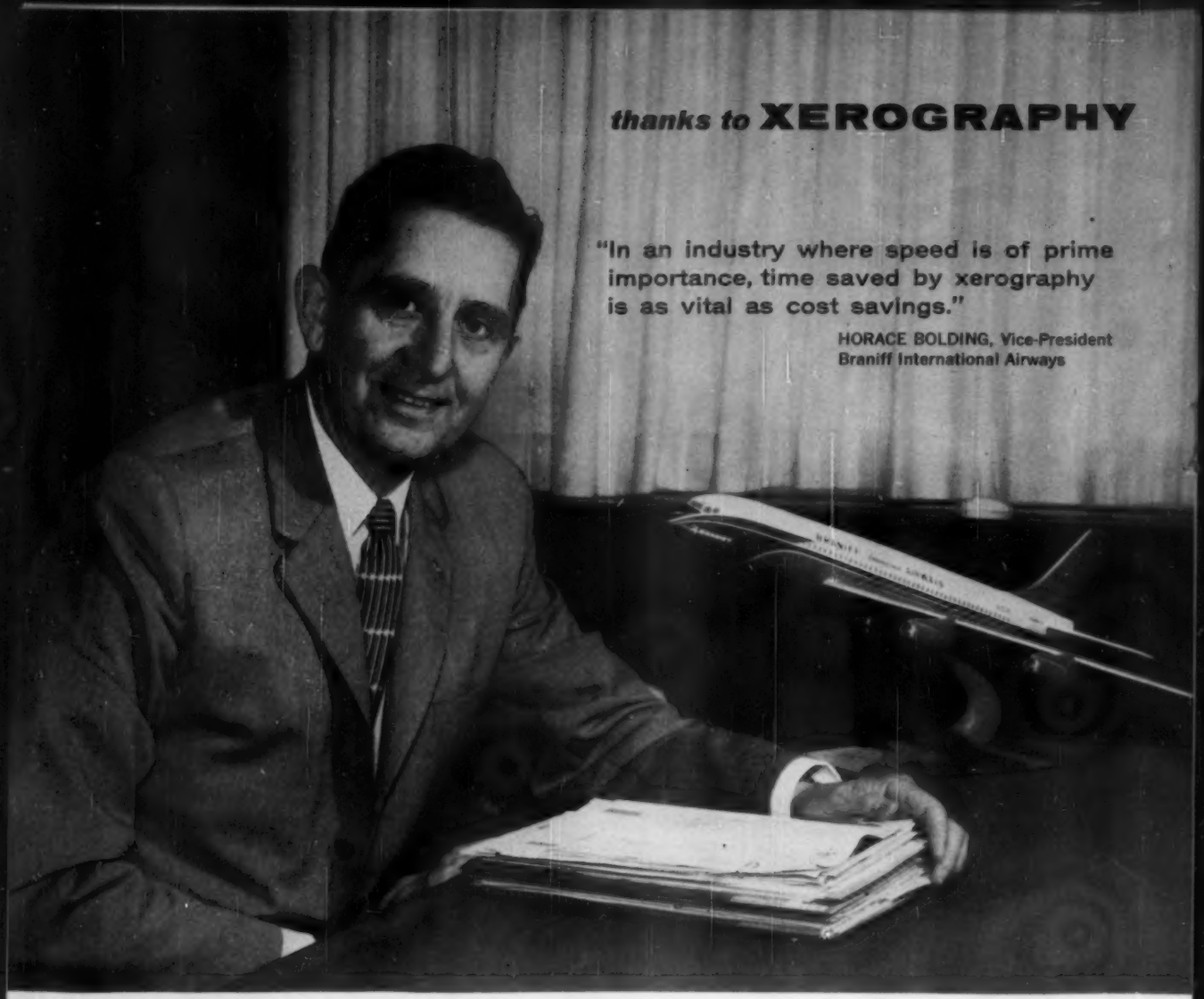
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FULLY TRANSISTORIZED

No Stepping Switches • No Relays

● **VERSATILE** accurately measures both resistances and AC-DC voltages and counts external events, too! Directly drives printers, punches and memory storage units and can be directly used as a bi-directional telemeter.

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True dependability and versatility have at long last come to digital volt-ohm meters in EPSCO'S new DVOM. Fully transistorized . . . adjustment-free . . . no stepping switches or relays. Provides precise numerical measurement of AC-DC voltages, resistances . . . fast, accurate visual or printed quality control data . . . high-speed data acquisition for direct print-out or storage . . . remote indication and data transmission over a single line. Compact, lightweight, portable — also for rack-mounting. Write for Bulletin 95801, Epsco, Inc., Equipment Division, 588 Commonwealth Ave., Boston 15, Mass.; in the West: Epsco-West, 125 E. Orangethorpe Ave., Anaheim, California

DVOM price.....$1,475

Ask for a demonstration.

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First in data control

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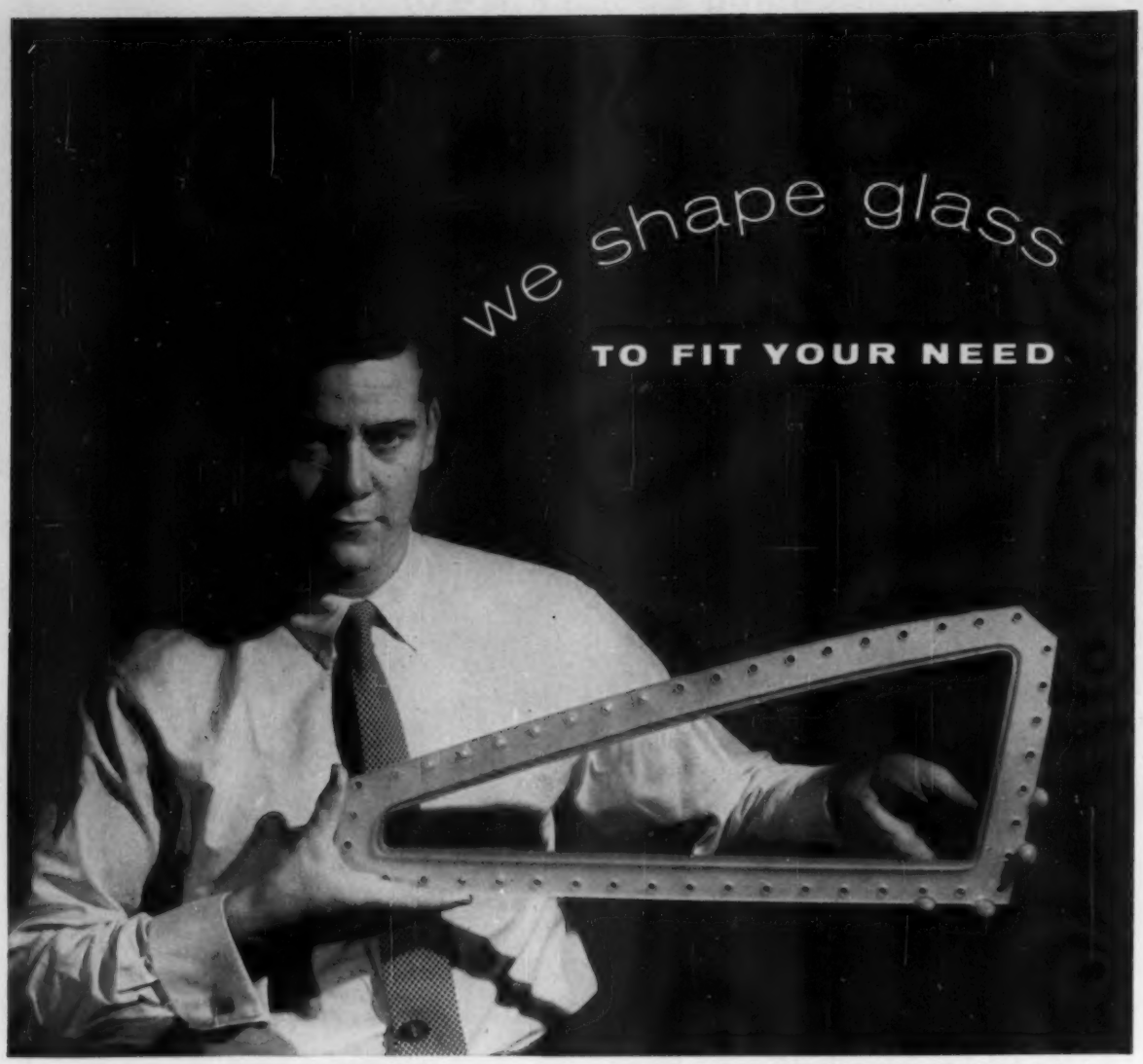

This curved Silicone glass panel is used on the Convair B-58 jet bomber.

Need glass that's stronger than some metals? Lighter than aluminum? Sensitive (or insensitive) to light, heat or electricity? Corrosion resistant, nonabsorbent, or low in contraction or expansion? These are among the many glass characteristics L·O·F has provided for aircraft design and safety requirements.

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A NEW SERIES OF STANDARD b/b SPLINES AT LESS THAN HALF FORMER COST!

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Good news for machine tool, aircraft and other designers! Standardization and volume production economies now enable you to take full advantage of this revolutionary ball/bearing Spline, built on the same gliding ball principle pioneered by the famous Saginaw b/b Screw.

Wherever easy linear movement is required under high torque load, Saginaw Standard b/b Splines offer:

- ***Freedom from Frictional Heat*** • ***Minimum Radial Lash***
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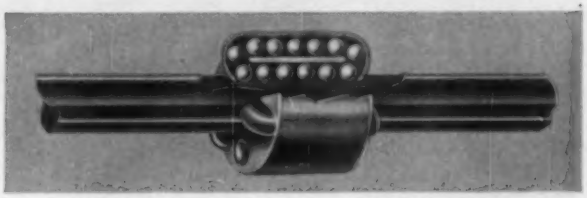
These new low-cost Standard b/b Splines are high commercial quality with excellent precision and service life, suitable for all but the most critical applications. Yet they cost about the same as high-friction splines.

TRANSMIT OR RESTRAIN HIGH TORQUE LOADS NO OTHER SPLINE CAN HANDLE

Standard b/b Splines are so friction-free that they permit previously impossible applications under very heavy torque loads, where the effort required to slide conventional splines would exceed the structural strength of members. They literally let you achieve the "impossible"!



Saginaw b/b Splines transmit or restrain high torque loads with far less friction because mating surfaces *glide* on rolling balls instead of *sliding* back and forth. Steel balls recirculate in closed circuits formed by mating longitudinal raceways spaced around the circumference of inner and outer parts.

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Can be fitted with integral gears, clutch dogs, bearing and sprocket seats or other attachments for use with electrical, hydraulic or pneumatic units.

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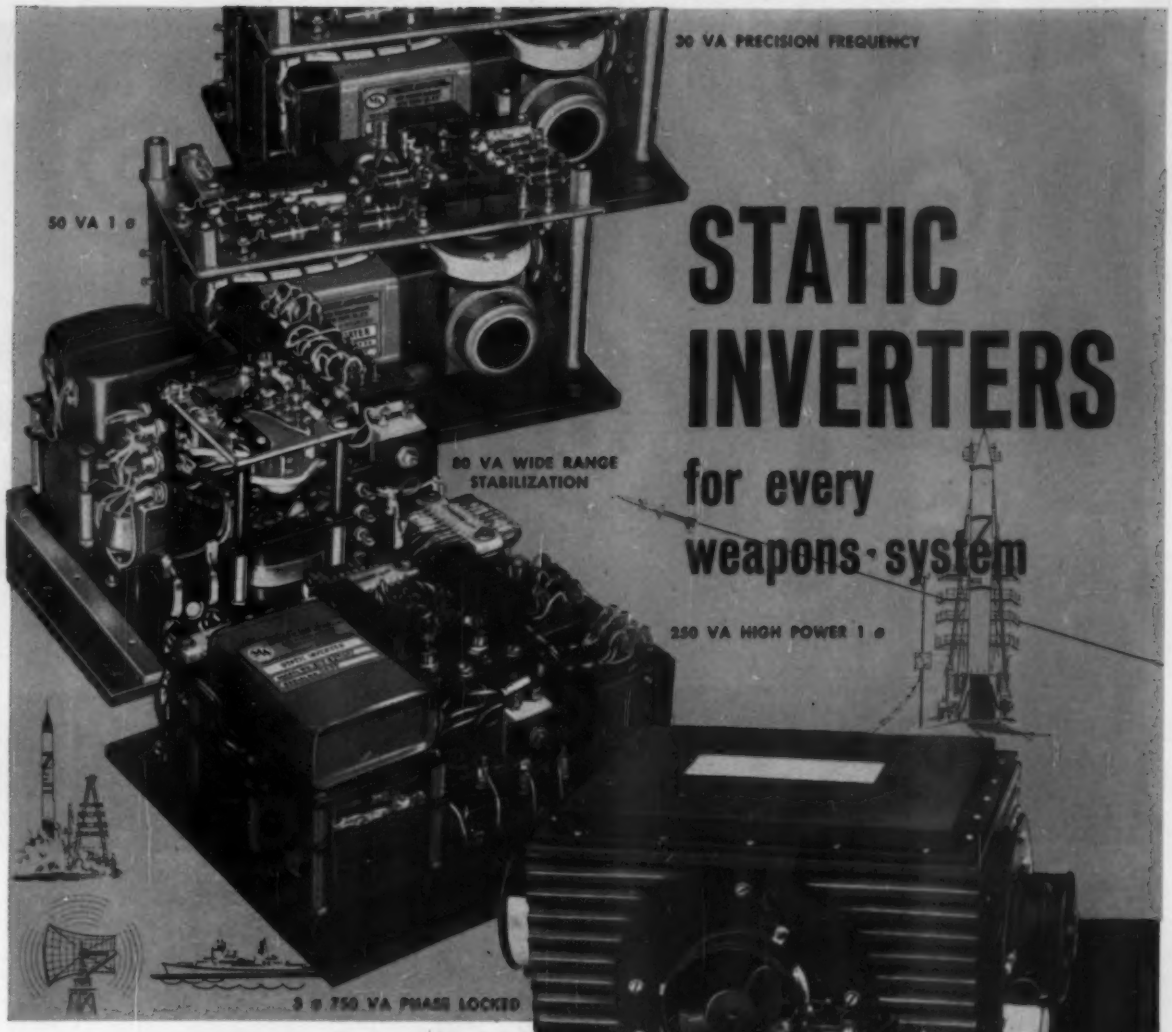

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Pioneering a new Northrop family of economical manned aircraft for the space age, the Talon is a direct result of teamwork between Norair and suppliers. This T-38 Team that made the trainer a reality is now producing it under USAF contract at Hawthorne, California. Soon to follow is the N-156F multi-purpose fighter, American-designed for our free-world allies.

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TYPE PT	TYPE PC	TYPE SP
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Wall Mounting Receptacle	Cable Connecting Plug
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CIRCLE NO. 47 READER SERVICE CARD 47

KLIXON®

CIRCUIT BREAKERS, PRECISION THERMOSTATS, SWITCHES and OVERHEAT PROTECTORS

For Electronic, Radar and Radio Equipment, Ground Support Equipment, Missiles and Aircraft Controls

KLIXON KX-5 SERIES PRECISION SWITCHES

Hermetically sealed snap-acting limit switches. Seal uses metalized ceramic terminal inserts and metal diaphragm. Switching element, one-piece sine blade. Steel case withstands high impact and compression loads. High temperature resistance to 375°F. Vibration resistance to 25 g's, 0-2500 cps. Ratings to 10 amperes, 115 VAC or 30 VDC resistive. 25,000 cycles minimum life. Ambient temperatures range, —65°F to +375°F. Weight 1 oz. Variety of actuators available.

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Hermetically sealed, vibration resistant, snap action. Gold plated contacts for dry circuit applications. Conforms with MIL-E-5272A and MIL-T-5574A. Preset and non-adjustable. Temperature settings from —65°F to +400°F. High dielectric strength 1250 VAC. Ratings up to 7 amperes, 30 VAC/DC resistive; or 6 amperes, 125 VAC; or 3 amperes, 250 VAC. Weight 5 grams. Special high-reliability version with low differential (9°F) available.

NEW KLIXON 2082 PRECISION THERMOSTAT

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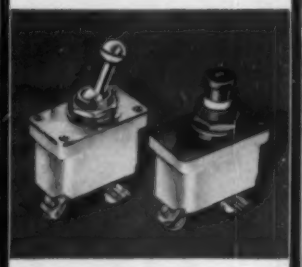
Simple push-pull, trip-free design. Available as shown SPST with 6/32 screw-type terminal or mounting to replace NAF-1357 front-mounted fuse. Also SPDT with N/O auxiliary contacts and 4 solder terminals. Exceptionally small — height 1.420", width 0.744", depth 0.562". Ratings ½ to 5 amperes. Ultimate trip @ 77°F, 115-145%. 200% trip, 2-15 seconds. Vibration resistance 10 g's, 10-500 cps. Shock resistance 25 g's. Weight only 0.9 oz.

NEW KLIXON D6786 SIMULTRIP* CIRCUIT BREAKER

Thermal type, three phase. Interrupts high AC short circuits . . . trips quickly . . . provides simultaneous tripping of all three phases should any one phase become overloaded. Phases can be different ratings. Ratings 5 to 60 amperes. 120/208 VAC, 60/400 cycle systems and 220/440 VAC, 60/400 cycle systems. Weight 227 grams. Minimum AC rupture capacity 2500 amperes, 1 ϕ, 120 VAC, 400 cps. Ultimate trip @ 77°F, 105-130%. 200% trip, 10-65 seconds.

*Trade Mark



KLIXON D7270-D7271 CIRCUIT BREAKERS

Two miniature breakers different only in actuators. Simple trip-free design about ½ the size of MS25005 and MS25017. Only three moving parts — actuator, slide and thermal disc. Ratings 3 to 35 amperes; weight 1.5 ozs. High rupture capacity 3500 amperes, 120 VAC, 400 cps; 4,000 amperes, 30 VDC.

KLIXON SINGLE-PHASE INHERENT OVERHEAT PROTECTORS

Protect transformers, solenoids, electric motors against excessive temperatures. Responsive to both temperature and current. These types are for single-phase inductive equipment with maximum continuous operating temperatures up to 225°C. Maximum rupture capacity is 750 amperes, 200 VAC, 400 cycle. Available in automatic and non-automatic reset types.

NEW KLIXON THREE-PHASE INHERENT OVERHEAT PROTECTORS

Designed to match the thermal and electrical characteristics of inductive equipment, they prevent protected components from reaching destructive temperatures without limiting useful output. For 3-phase equipment with maximum continuous operating temperatures up to 225°C. Maximum rupture capacity is 400 amperes, 200 V, 400 cycles. Available in open and hermetically-sealed construction in automatic and non-automatic reset types.

KLIXON Circuit Breakers, Precision Switches, Precision Thermostats and Overheat Protectors are small in size and light in weight; they respond quickly and with accurate repeat performance; they have ample capacity to handle a wide range of electrical loads; their calibrations stand up in the face of severe environmental conditions.

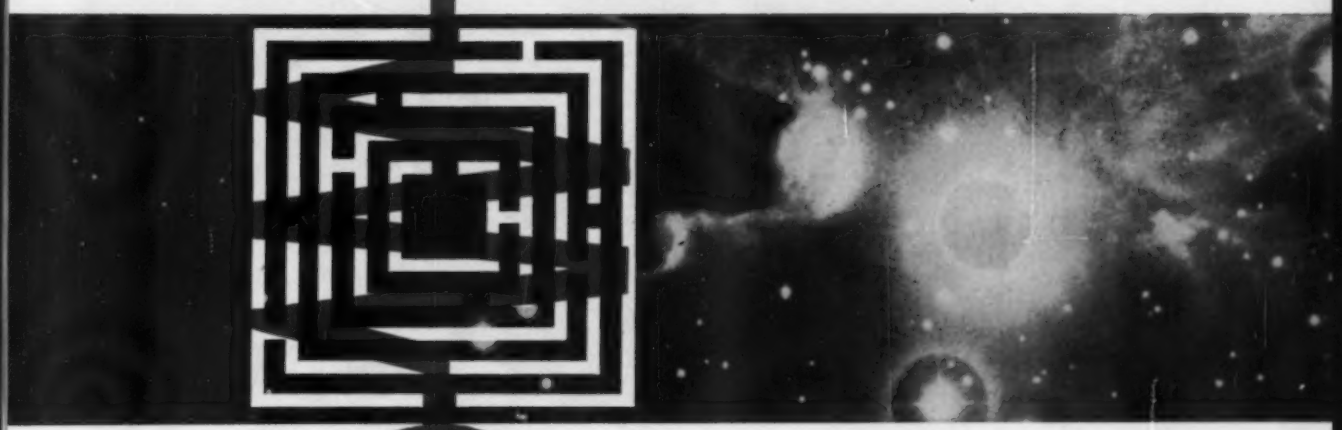
Competent Metals & Controls engineers at the factory and in the field will gladly make test applications of the KLIXON Line. Write for "KLIXON Controls for Electronic Equipment, Aircraft and Guided Missiles" Catalog.

METALS & CONTROLS

2806 34 FOREST STREET, ATTLEBORO, MASS., U. S. A.

A DIVISION OF TEXAS INSTRUMENTS INCORPORATED

SPENCER PRODUCTS: Klixon® Inherent Overheat Motor Protectors • Motor Starting Relays • Thermostats • Precision Switches • Circuit Breakers



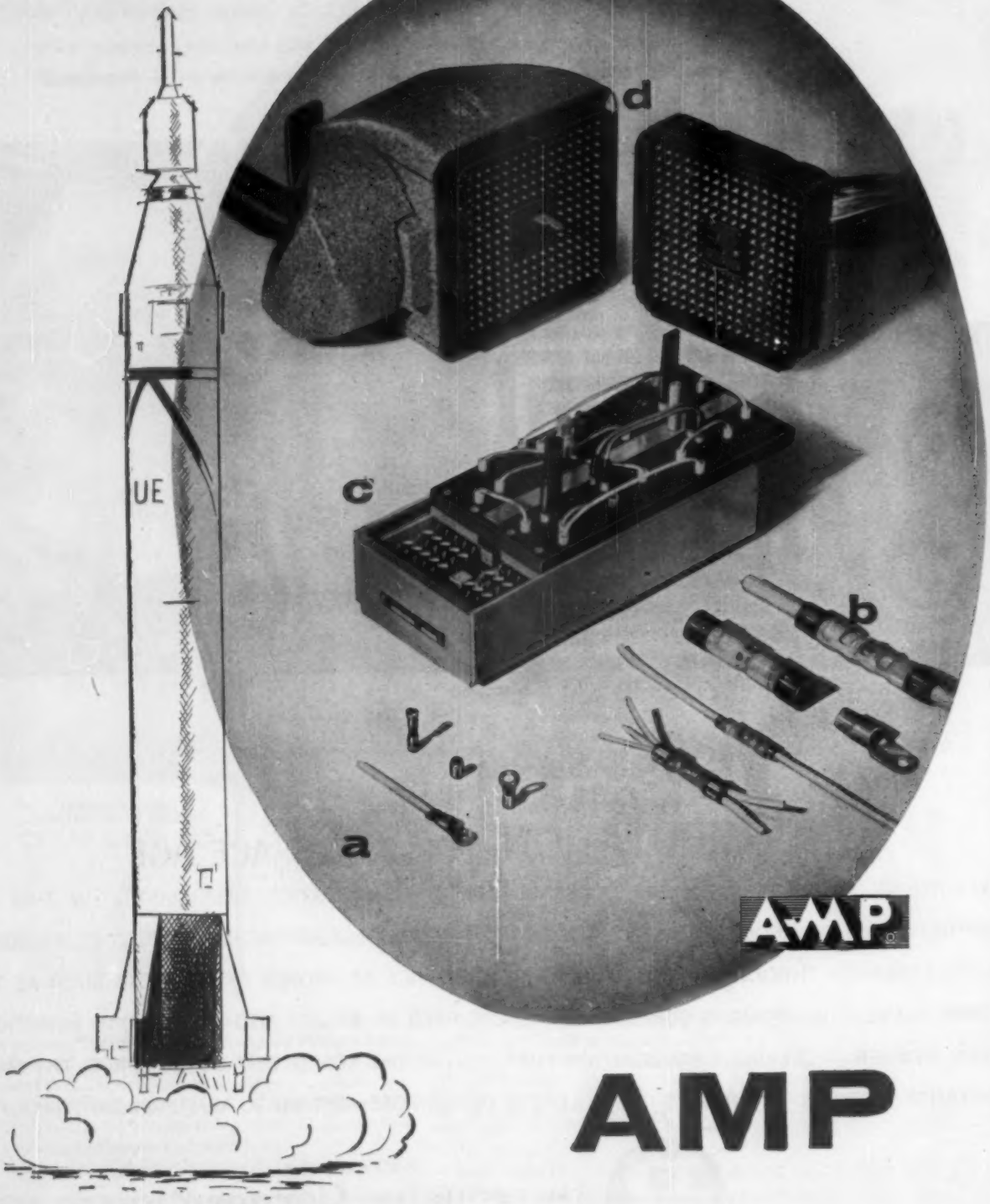
COMPUTATION FOR THE SPACE AGE

EXPEDITIONS INTO SPACE FOLLOW TRAILS BLAZED BY COMPUTATION SPECIALISTS. IN THIS HIGHLY SOPHISTICATED TECHNOLOGY, BURROUGHS CORPORATION'S DEMONSTRATED COMPETENCE RANGES FROM BASIC RESEARCH THROUGH PRODUCTION TO FIELD SERVICE AS PROVED BY PROJECTS SUCH AS THE AIR FORCE ATLAS. BURROUGHS CORPORATION IS EQUIPPED BY ABILITY AND ATTITUDE TO FUNCTION AS A TEAM MEMBER—A CLEARCUT RECOGNITION THAT EVEN IN THE REACHES OF OUTER SPACE, THE SHORTEST DISTANCE BETWEEN TWO POINTS IS SINGLENESS OF PURPOSE APPLIED TO MUTUAL OBJECTIVES.

Burroughs Corporation

"NEW DIMENSIONS / in computation for military systems"

because CIRCUIT



AMP

RELIABILITY is Vital...

. . . AMP's product is more than fine circuit terminals . . . more than remarkably precise compression-crimp tooling . . . more than an error free, fast method of attachment.

AMP's product is finished crimp-type terminations on your circuitry wires . . . by the hundreds or millions . . . of the highest reliability . . . performing under gruelling conditions . . . from basic terminals to complete patchcord systems.

Listed here are a few of the more than 15,000 circuitry items that AMP INCORPORATED has developed.

a STRATOTHERM TERMINALS AND SPLICES FOR APPLICATIONS WITH CRITICAL THERMAL FACTORS

- up to 1200°F. operating temperature
- solid, stranded or combination conductors
- shock and corrosion resistant
- wire size range 22-10 AWG
- serrated inner barrel for maximum tensile strength

---

b CERTI-SEAL AND Ampli-NYL SPLICES

- combined wire size range 22-2/0 AWG
- exceed millivolt-drop specifications
- finest nylon pre-insulation
- shock and corrosion resistant
- color coded by wire size

---

c A-MP PATCHCORD PROGRAMMING SYSTEMS AND PANELS FOR COMPUTERS, TELEMETERING EQUIPMENT AND AUTOMATION ("240" Airborne Unit illustrated)

- universal or shielded systems
- patented wiping action pre-cleans pins and contact springs
- nylon sleeve insulates and firmly seats patchcord pin in board
- contacts have rear board accommodation for taper pins to provide reliable solderless lead terminations

---

d 200 CONTACT CABLE CONNECTOR FOR CRITICAL MULTIPLE WIRING APPLICATIONS

- voltage rating: 1,000 volts A.C., R.M.S.; current rating in excess of three amperes
- connector can be electrically disengaged without mechanical separation
- five indexed positions to permit strain-free cable entrance
- identical boards and contacts in both halves
- polarized to prevent improper coupling—has numbered cavities to assure proper circuit identification.

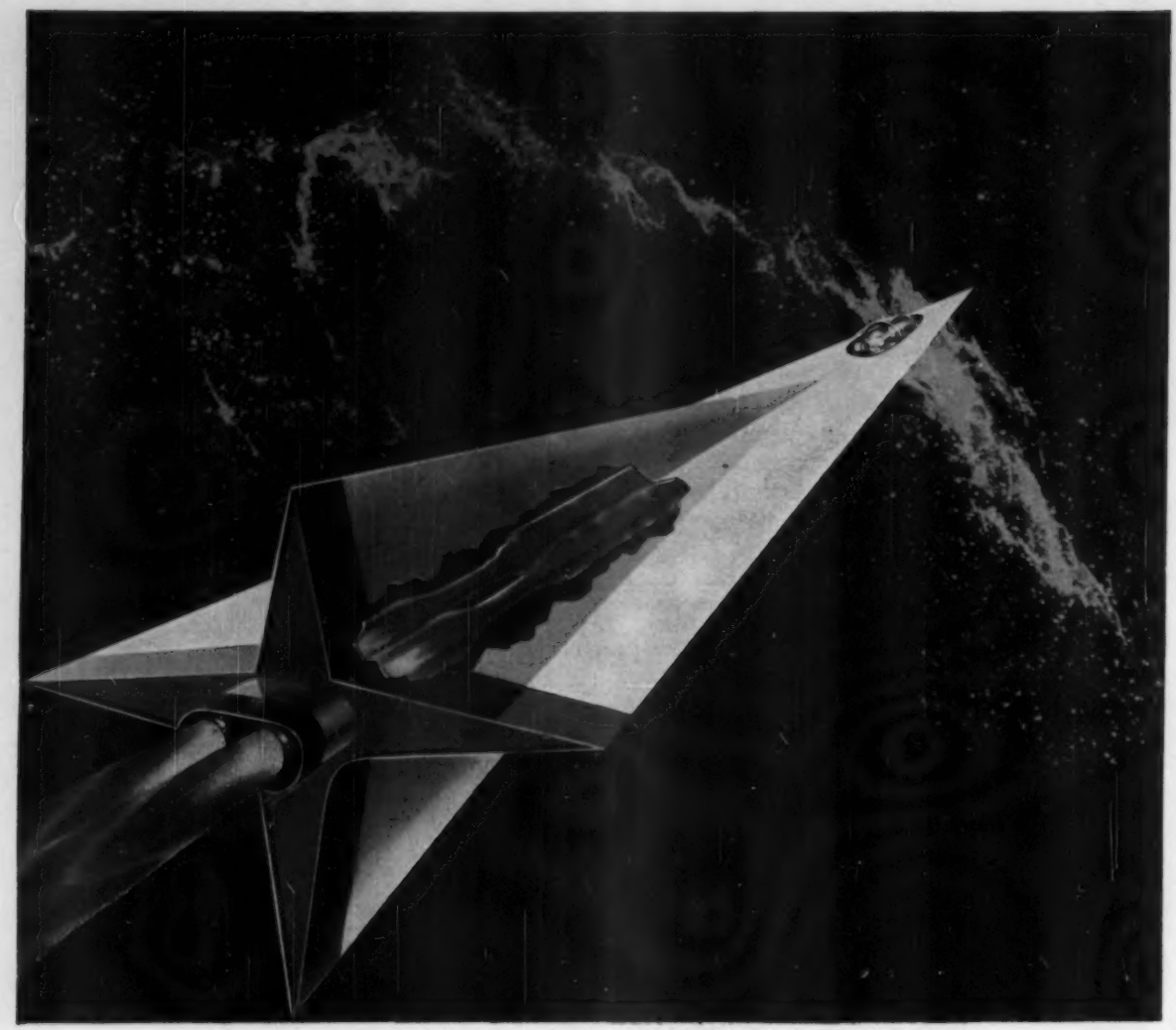
Complete information on these four product lines is available on request.

INCORPORATED

GENERAL OFFICES: HARRISBURG, PENNSYLVANIA

A-MP products and engineering assistance are available through subsidiary companies in: Canada • England • France • Holland • Japan

CIRCLE NO. 51 READER SERVICE CARD 51



Baby, it's HOT inside .....

• TYPICAL OF ROLLWAY R & D WORK IS THIS JET AIRCRAFT HYDRAULIC PUMP BEARING, FEATURING A BROACHED INNER RACE.

No matter where it comes from . . . ultra-high angular velocities, skin-friction, conduction or radiation from the burners . . . today's airborne bearings spin in temperatures that approach ever closer to the softening point of conventional steels.

Unceasing research work here at Rollway strives for new understanding and control of limiting forces . . . and for practical metallurgical combinations that will enable aerodyne engines to fly faster, higher and further with less mechanical friction drag.

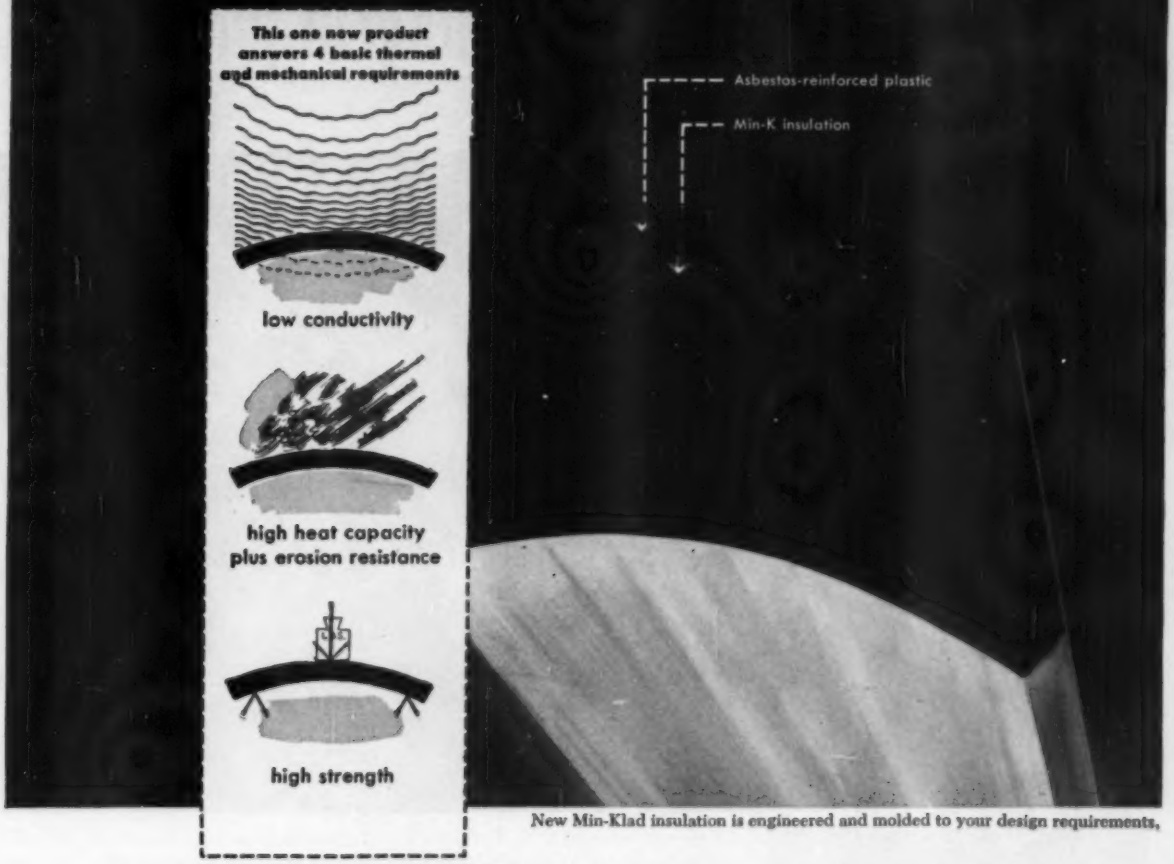
Rollway service extends all the way from down-to-earth estimates of lead time to closely-held schedules of delivery dates. Maybe we have what you want now on test. Costs nothing to find out. Just write or wire Rollway Bearing Co., Inc., 582 Seymour St., Syracuse 4, N. Y.

ROLLWAY®
BEARINGS

COMPLETE LINE OF RADIAL AND THRUST CYLINDRICAL ROLLER BEARINGS

ENGINEERING OFFICES: Syracuse • Boston • Chicago • Detroit • Toronto • Pittsburgh • Cleveland • Seattle • Houston • Philadelphia • LosAngeles • SanFrancisco

Johns-Manville announces new **MIN-KLAD** Insulation!


This one new product answers 4 basic thermal and mechanical requirements
low conductivity
high heat capacity plus erosion resistance
high strength
Asbestos-reinforced plastic
Min-K insulation

New Min-Klad insulation is engineered and molded to your design requirements,

Combines the capabilities of asbestos-reinforced plastic with the dramatically low conductivity of MIN-K insulation!

New Min-Klad insulation may well be the most significant advance ever made in missile and rocket insulation.

Developed by Johns-Manville research scientists, Min-Klad is the only product of its kind, a permanent lamination of the missile industry's two most effective high-temperature materials: 1) reinforced plastic and 2) J-M's recently developed Min-K insulation.

Does more than plastic alone

Min-Klad gives the missile designer all the advantages of high-temperature plastic: Strength, toughness, rigidity! Erosion resistance! High heat capacity! Yet Min-Klad does more.

It also insulates . . . and with dramatic effectiveness! Its insulating element is J-M's Min-K, an insulation with thermal conductivity that is actually lower than the molecular conductivity of still air. And this conductivity (already less than half that of the best fibrous insulations) drops still further with altitude. At 10 miles, for example, it is decreased by as much as 40%, with further decreases at greater altitudes.

Wide range of applications

Min-Klad offers the missile and rocket designer a rich choice of heat-control possibilities. It may be used for a part that must insulate, yet have the structural advantages of plastic. Where requirements call for a scuff- and erosion-resistant insulating surface . . . or for a good adhesive bond between Min-K insulation and other surfaces. Or, it may be used to control high transient temperatures! For high heat capacity of asbestos-reinforced plastic combined with the low conductivity and heat capacity of Min-K result in a product that provides minimum heat transfer under transient conditions.

Min-Klad is now being tested for approximately two dozen missile and rocket designs. Why not investigate this new material for your present thermal requirements? Upon request, we'll be pleased to send you a sample of the material along with detailed technical information. Write Johns-Manville, Box 14, New York 16, New York. (Ask, too, for information on Min-K insulation and the new aviation insulation brochure IN-185A.) In Canada: Port Credit, Ontario.

JOHNS-MANVILLE JM PRODUCTS

CIRCLE NO. 53 READER SERVICE CARD 53

Armco PH 15-7 Mo Stainless Selected for the B-70 Valkyrie and F-108

It's the primary sheet metal for construction of newest air weapon systems being developed and built by Los Angeles Division of North American Aviation, Inc.

The B-70 Valkyrie and the F-108, Mach 3 aircraft designed for 70,000 ft. altitudes, will add powerful long-range weapons to America's air armor. Both the dramatically-new intercontinental bomber and the interceptor being created by North American, in collaboration with a team of major defense firms, are to be constructed primarily of stainless steel.

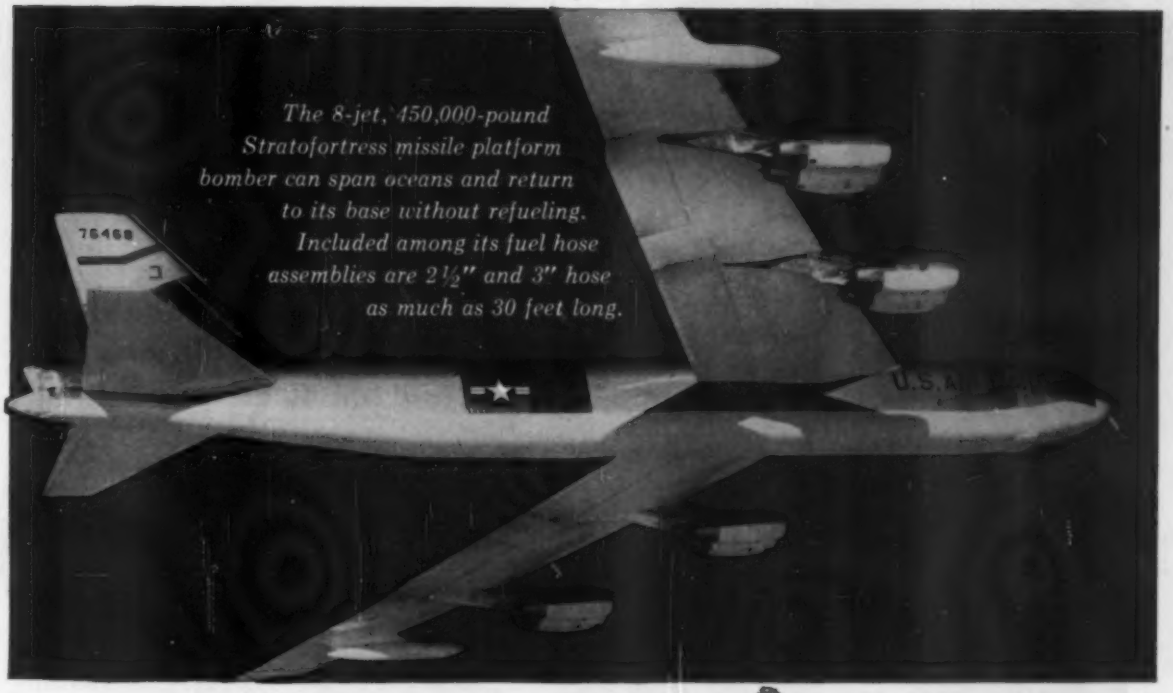
Because Armco PH 15-7 Mo Stainless maintains its strength at the high temperatures caused by speeds exceeding 2000 mph, it has been specified for the major parts of the airframes.

This special stainless steel, in foil and sheets, will be fabricated into high strength, honeycomb panels for wings, fuselages, and control units. It will also be used for other key structural elements of both aircraft.

Selection of Armco PH 15-7 Mo, newest of Armco's widely used family of precipitation-hardening stainless steels, demonstrates the superiority of this high strength, heat and corrosion resistant metal. For complete information on the properties and fabrication of Armco PH 15-7 Mo Stainless Steel, write Armco Steel Corporation, 2539 Curtis Street, Middletown, Ohio.

ARMCO STEEL

Armco Division • Sheffield Division • The National Supply Company • Armco Drainage & Metal Products, Inc. • The Armco International Corporation • Union Wire Rope Corporation • Southwest Steel Products


The 8-jet, 450,000-pound Stratofortress missile platform bomber can span oceans and return to its base without refueling. Included among its fuel hose assemblies are 2½" and 3" hose as much as 30 feet long.

75 Fuel Line Assemblies on B-52G . . .

Completely New . .

Developed and Produced by

WEATHERHEAD

The Weatherhead fuel line system for Boeing's B-52G meets heretofore unknown requirements in terms of operating characteristics, material properties, light weight and unusually large range of sizes (1½" to 4" I.D.) Approximately 75 different assemblies provide continuous distribution of fuel in the integral wing and fuselage tanks to the eight jet engines. The special hose is impervious to the JP-4 or JP-5 fuels employed, even where it remains immersed in fuel.

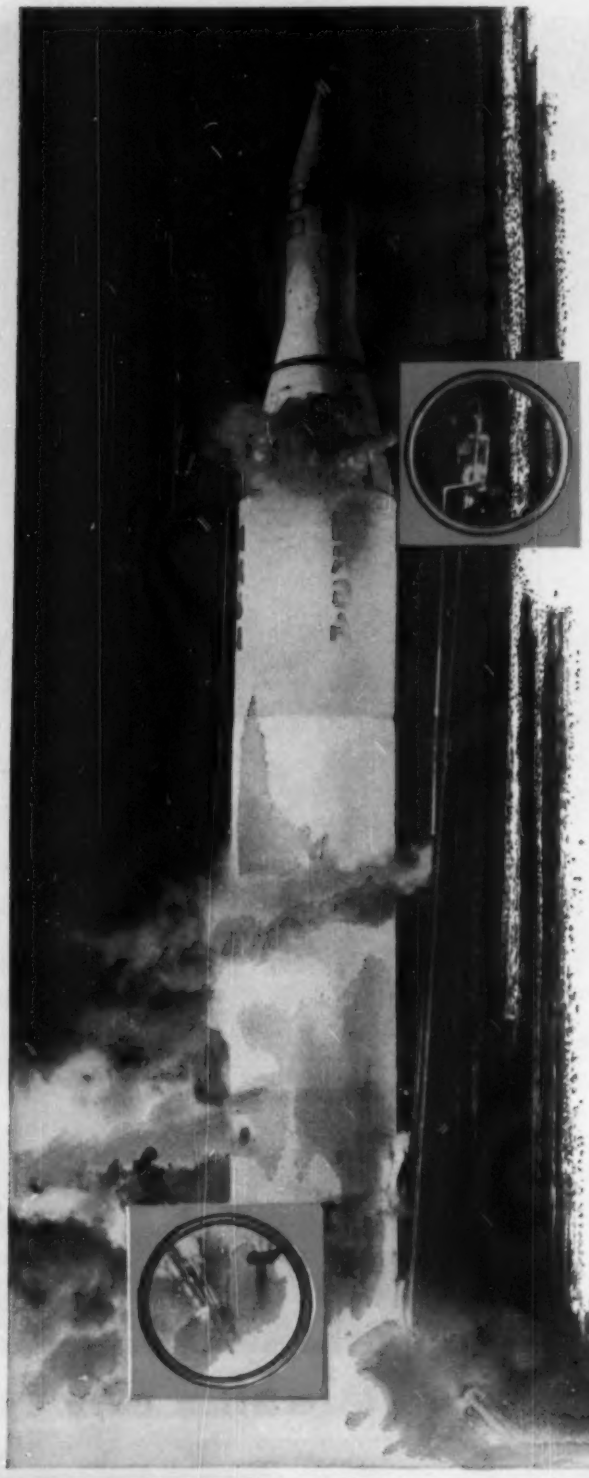
In developing the entirely new hose assemblies, Weatherhead worked on the specifications with Boeing engineers. Shortly afterward, Weatherhead had established mass production of the full range of qualified assemblies.

This is an example of how Weatherhead smoothly synchronizes its vast research and development, engineering and manufacturing facilities to originate and supply special needs within tight timetables. Whatever your fluid system requirements, look to Weatherhead for assistance from concept through production.

WEATHERHEAD AVIATION and MISSILE GROUP

In Canada: 127 Inkerman Street, St. Thomas, Ontario • Export Cable Address: WEATHCO, Cleveland

CIRCLE NO. 55 READER SERVICE CARD 55



SEALING UNLIMITED

...with United Metallic O-Rings!

meeting such challenges as –320°F... 1200°F... 40,000 psi

No one at United has thrown a towel into the O-ring for a long time! This despite the fact that static sealing requirements for space flight and nuclear power constantly grow tougher and tougher. By combining imaginative engineering with product superiority, United has met a long series of challenges involving metallic O-ring seals. For example, United Metallic O-rings have satisfied requirements on such unusual static seal assignments as:

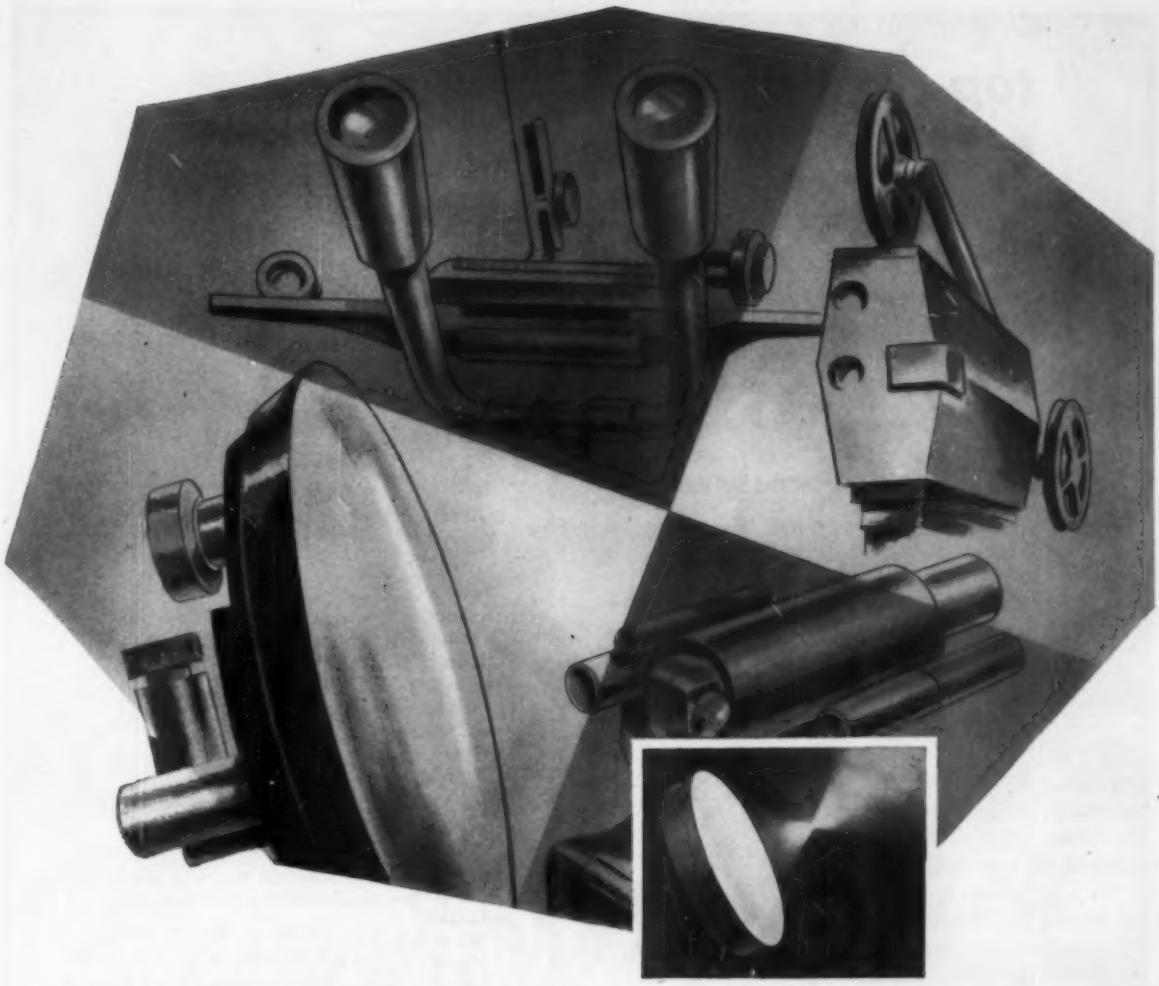
Reactor Pressure Vessel 490°F/600 psi
Waveguide Flange 300°F/60 psi
Internal Hydrostatic Pressure 40,000 psi
Nuclear Apparatus 1200°F/400 psi
Oxygen–320°F/200 psi
Helium 1200°F/400 psi
Water 100°F/3750 psi
Vessel Closure 1000°F/1200 psi
Space Test Chamber 10^{-6}mm Hg Vacuum/–320°F

Whether you're shooting for the moon... or your sealing problem is merely downright earth-shaking, United can supply the necessary metal-to-metal, non-corrosive, long-life seals! Write or phone:

ask for new handbook... available June 15

CALIFORNIA.....1101 Chestnut St., Burbank, VI 9-5856
NEW YORK.....50 E. 42nd St., New York 17, MU 7-1283
OHIO.....1116 Bolander Ave., Dayton, BA 4-3841
CANADA.....United Aircraft Products Ltd., 147 Hymus Blvd., Pointe Claire, P.Q., Phone Montreal: OX 7-0810

UNITED METALLIC "O" RING
Division of **United Aircraft Products, Inc.**
Dayton, Ohio • Box 1035



Unbreakable Repli-Kote Mirrors out-perform glass, slash costs

These new lightweight, low distortion Repli-Kote Mirrors of cast epoxy resin offer design engineers optical reflectors with a matchless combination of properties, impossible with glass. A single master mirror is all that's necessary for mass producing precision Repli-Kote Mirrors—at significant cost savings.

Optical Precision — 6"—5¼" Focal Length Repli-Kote paraboloid mirrors have been produced in quantity with an accuracy permitting 90% of incident collimated light to be concentrated within a disc of 0.1 mm diameter. Higher rate of thermal diffusion through epoxy also lowers distortion caused by temperature transients.

Permanent Reflective Surface — High vacuum applied, silicon monoxide protected aluminum reflective surface is *permanently* bonded to epoxy backing, will resist flaking or peeling for extended periods.

High Mechanical and Thermal Shock Resistance — Repli-Kote Mirrors have withstood impacts *as severe as 22,000 g*, undergone rapid temperature cycling from −55°C to +125°C with no measurable physical change.

Light Weight—Repli-Kote Mirrors cast of epoxy are much lighter than glass. Suitable fillers can be added if desirable.

Any Shape—Paraboloids, hyperboloids, ellipsoids and more complex aspheric surfaces not previously reproducible in glass by mass production methods can now be quickly fabricated.

Ease of Mounting—Fixtures, threaded inserts, electrical components can be molded directly into the mirror backing, opening an almost limitless field of design possibilities. Repli-Kote Mirrors are also easily machined.

If you are working on tracking and guidance systems—or any system employing reflective optics—durable, lightweight, precision Repli-Kote Mirrors offer you greater design and production freedom. Let us help you make the most of Repli-Kote Mirrors in building a better product at lower cost.

Address Inquiries *to Repli-Kote, Singer-Bridgeport, 915 Pembroke Street, Bridgeport 8, Conn.*

SINGER

MILITARY PRODUCTS DIVISION

THE SINGER MANUFACTURING COMPANY

Military Products Division • 149 Broadway, New York 6, N. Y.

HRB • DIEHL • BRIDGEPORT

1383

CIRCLE NO. 57 READER SERVICE CARD 57

Clary introduces a new concept in valve design...

top-performing economical regulators

Here at last...hand-loader type regulator valves that are economical in the true sense of the word!

First, they are far less expensive than regulators of comparable quality and performance specifications. This low price is made possible by a unique, simplified design and by Clary's years of design and manufacturing experience.

Second, their ease of maintenance saves valuable man-hours. There's no need to remove the entire unit should failures occur – a simple replacement of the "O" ring seal does the job quickly and easily.

Third, because they are adjustable over an extremely wide range of pressures, you can use them in a variety of applications.

To find out more about these exceptional regulators, send for technical bulletin #CD-150. And whenever precision, reliability and versatility are factors in your plans, call on Clary for complete services.

HAND-LOADER PRESSURE REGULATOR

Port Size: ¼ Tube Per AND 10050

Pressure Characteristics:

A. Operating	B. Proof
Upstream 4000 PSIG Max.	Upstream 6000 PSIG
Downstream 3000 PSIG Max.	Downstream 4500 PSIG

Service: Air, Nitrogen, Helium

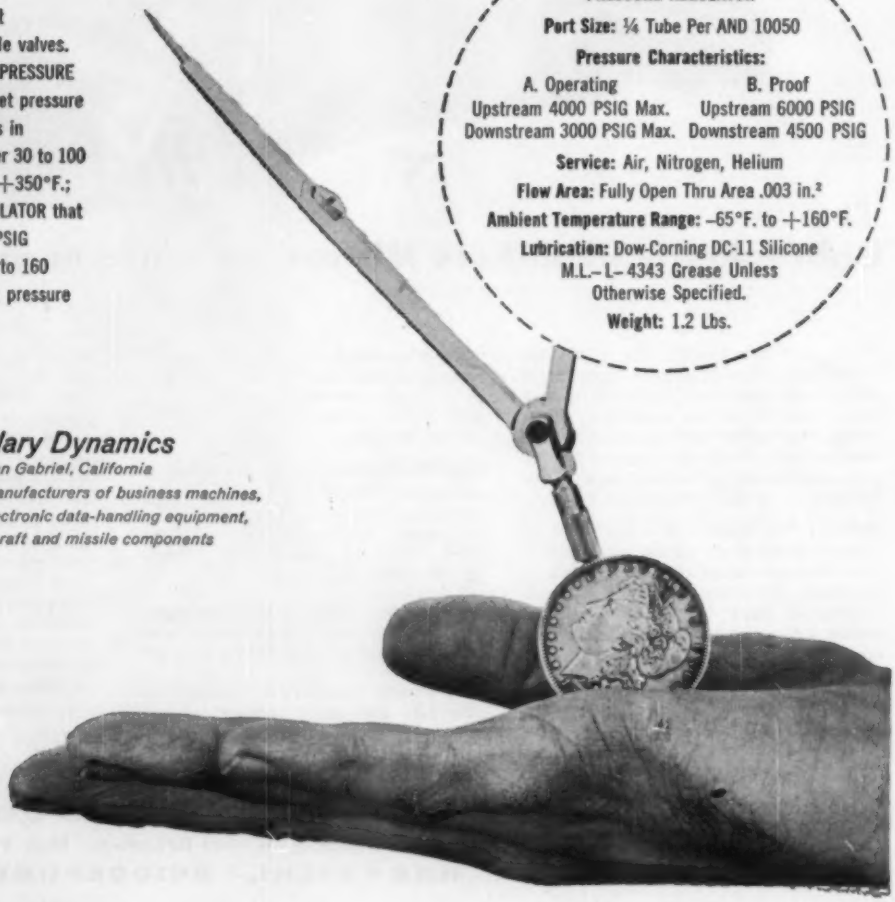
Flow Area: Fully Open Thru Area .003 in.²

Ambient Temperature Range: –65°F. to +160°F.

Lubrication: Dow-Corning DC-11 Silicone M.L.–L–4343 Grease Unless Otherwise Specified.

Weight: 1.2 Lbs.

Clary is one of the nation's largest manufacturers of rocket and missile valves. Other devices include: ABSOLUTE PRESSURE REGULATOR that maintains an outlet pressure of 18½ to 20 PSIA with variations in flow rate from 3 to 350 SCFM under 30 to 100 PSIA inlet pressure and –65°F. to +350°F.; and DIFFERENTIAL PRESSURE REGULATOR that maintains an outlet pressure of 6 PSIG ±.25 with flow variations from 3 to 160 SCFM under 10 to 250 PSIG inlet pressure and –65°F. to +350°F.



Clary

Clary Dynamics

San Gabriel, California

Manufacturers of business machines, electronic data-handling equipment, aircraft and missile components

OUTPERFORMING all operational target missiles, Ryan's *transonic* Firebee has just set new world's records for altitude and duration-at-altitude.

...it flies *higher*—59,000 feet

...it flies *longer*—96.8 minutes *(77½ minutes above 50,000 feet!)*

...it flies *faster*—Mach .95

Now being produced for the Air Force (Q-2C version), Ryan's new *transonic* Firebee contains advanced, built-in auxiliary devices to better simulate enemy aircraft. It has the performance needed to challenge America's most advanced weapon systems under realistic combat conditions.

The *transonic* Firebee is the result of Ryan's unmatched ten years of design and operational experience in the jet target field.

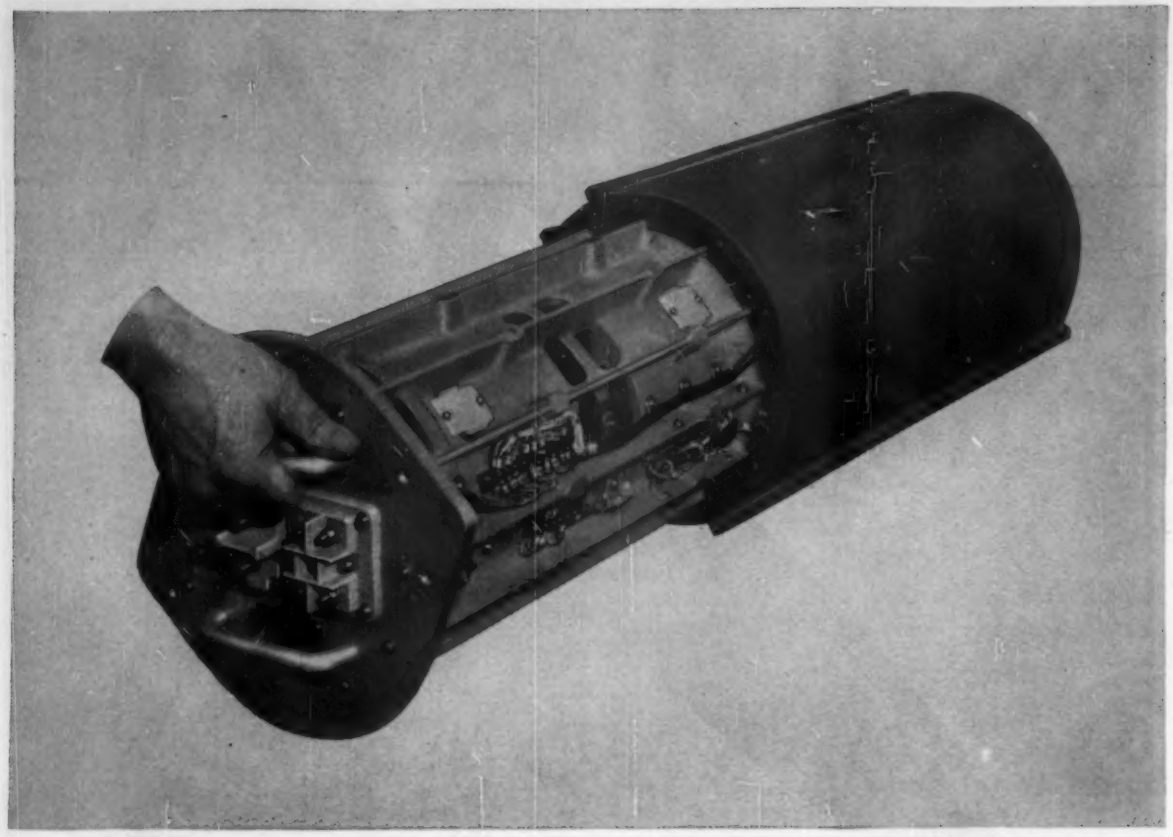
In 1949, Ryan built the first jet target missile ...today more Firebees are in service—with the Air Force, Navy, Army, and Royal Canadian Air Force—than all other jet targets *combined*...and now, with this new *transonic* Firebee, Ryan gives proof again of its continued leadership in the design and development of jet targets.

RYAN OFFERS CHALLENGING OPPORTUNITIES TO ENGINEERS

RYAN BUILDS BETTER

AIRCRAFT · POWER PLANTS · ELECTRONICS

Ryan Aeronautical Company, San Diego, Calif.



NEW! BENDIX CANISTERED INVERTERS

Withstand the Effects of Temperature, Vibration and Acceleration at Blast-off and Will Function Perfectly at Any Altitude, Including Outer Space

Bendix Canistered Inverters, environment-free and completely sealed, are now in production for the Atlas and Thor missiles. Designed for dependable and efficient operation, Bendix Canistered Inverters are completely sealed against the effects of altitude and can withstand conditions from sea level to outer space.

Cooling techniques employed enable these units to provide full-rated output throughout the flight without external cooling. Both voltage and frequency regulation are accomplished by static, magnetic amplifier-type regulators. Since these regulators have no moving parts, output voltage and frequency are not affected by vibration and shock. The total harmonic content of the output voltage per phase is less than 5%.

Bendix Canistered Inverters are the product of years of development and experience in manufacturing electrical power equipment for aircraft and missiles. They are engineered to meet the strenuous requirements in performance and reliability called for in today's (and tomorrow's) missiles. For more detailed information write TO RED BANK DIVISION OF BENDIX AVIATION CORPORATION, EATONTOWN, NEW JERSEY.

West Coast Sales and Service: 117 E. Providencia Ave., Burbank, Calif. Canadian Distributor: Aviation Electric, Ltd., P. O. Box 6102, Montreal, P. Q. Export Sales and Service: Bendix International Division, 205 E. 42nd St., New York 17, N. Y.

Red Bank Division

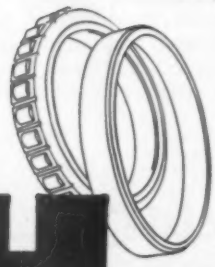
Bendix AVIATION CORPORATION

HYATT BEARINGS SPIN 56,700 rpm IN WORLD'S SMALLEST AIRCRAFT PROPULSION GAS TURBINE ENGINE!

TIE-DOWN TEST OF SOLAR GAS TURBINE ENGINE ON ONE-MAN HELICOPTER

HYATT HY-ROLL BEARINGS are used in the most critical part of the smallest gas turbine aircraft propulsion engine ever built for one-man helicopters and flying platforms. Developed and built by the Solar Aircraft Company, of California, this 55-70 horsepower, 20-inch-high power plant utilizes HYATT HY-ROLL BEARINGS on the turbine shaft revolving at a lightning 56,700 rpm!

For assured bearing dependability, follow the lead of the country's most prominent aircraft manufacturers . . . turn to HYATT!
Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey.



Another GM GENERAL MOTORS contribution to aviation progress

HYATT HY-ROLL BEARINGS FOR AIRCRAFT INDUSTRY

CIRCLE NO. 61 READER SERVICE CARD 61

Doesn't Miss a Trick!

... *The Fenwal Simultaneous Monitoring System*

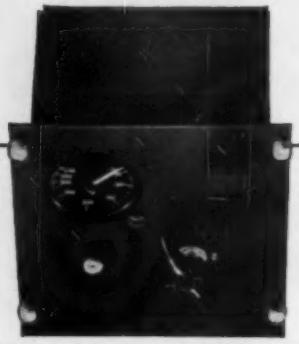
You always know the temperature condition at every point covered by this Fenwal Monitoring System. There's no switching from point to point. With each probe continuously "on duty" *it's literally everywhere at once!*

System's solid-state components are small, light, and wear-free — permit sensitive, reliable response. Fenwal thermistor sensors with practically infinite life change resistance sharply when temperatures go "off limits" . . . feed strong electrical signals to rugged, transistorized amplifier. *Tiny, they can go directly to the trouble spot!*

Fenwal Simultaneous Monitoring Systems are flying with all the new commercial jets and many missiles and military aircraft; in baggage compartments, leading edges, bleed air ducts, etc. They're repeatedly proving their "better engineering" by a company with highly integrated manufacturing facilities, including its own source of thermistors. *Truly "static" systems with dynamic capabilities!*

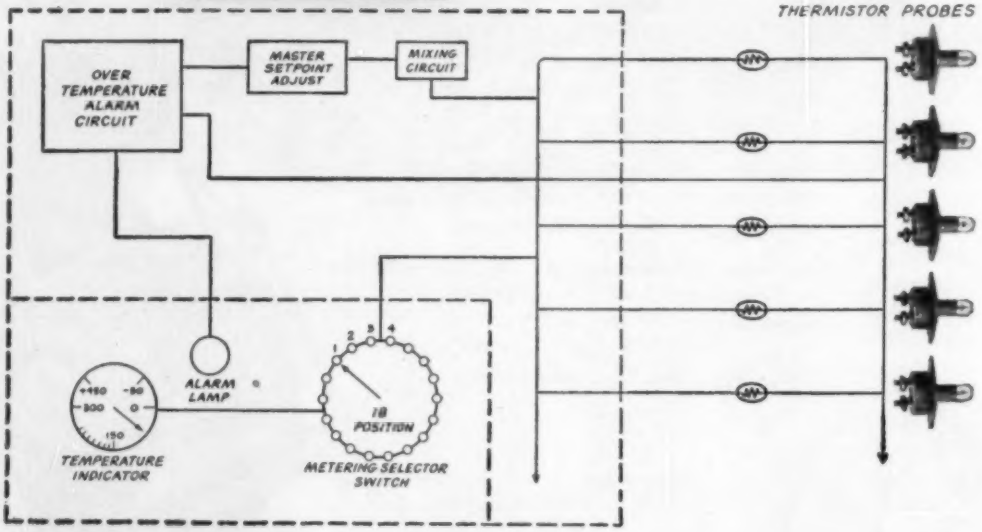
For complete details or complete engineering of *your* specific monitoring problem, write Fenwal Incorporated, 126 Pleasant Street, Ashland, Massachusetts.

***continuously** senses temperature at 100 or more separate points.*



Master warning of the Fenwal Simultaneous Monitoring System can be bell, light, or other alarm. Specific identification and read out of trouble spots can be made manually (shown) or completely automatically.

Dotted lines indicate contents of "black box". Eighteen points being monitored (five points shown for simplicity).



ANOTHER EXAMPLE OF HOW **Fenwal** CONTROLS TEMPERATURE . . . PRECISELY

Job routine?

Not at Convair-Fort Worth, for routine is a result of precedent, and there is scarcely any precedent in the shape of things at America's most advanced facility, devoted exclusively to the design and development of aerial weapons.

The forward and creative thinking of well trained, experienced engineers and scientists at Convair-Fort Worth has repeatedly produced solid evidence of this fact. From the basic concept of the engineering organization itself, to such advanced finished products as the B-58, there is scarcely room or time for tiresome routine to develop. Projects far beyond the state of the art represented by presently operating craft are continually providing new opportunities for men qualified to share in these ventures.

The current list of openings is headed by the need for men with experience in the design and testing of radomes, particularly those with boresight correction technique experience; structures and structural design engineers; and electronics engineers. Details available on request, or send a complete resumé for evaluation by our engineers, promptly and in strict confidence.

CONVAIR / FORT WORTH

P. O. Box 748-A

A DIVISION OF

GENERAL DYNAMICS

Movable bulkhead permits versatility in ratio of passenger-cargo space.

DC-6A cargo airliner converted to tourist seating arrangement.

Specially designed hat racks and cold air system quickly removable in sections.

Passenger windows added to cargo doors . . . installation of radar system, including radome.

Converting DC-6As Into Cargo-Passenger Airliners

AiResearch Aviation Service modifies to specific airline requirements

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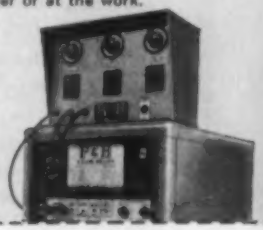

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June 22, 1959

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Including Space Technology

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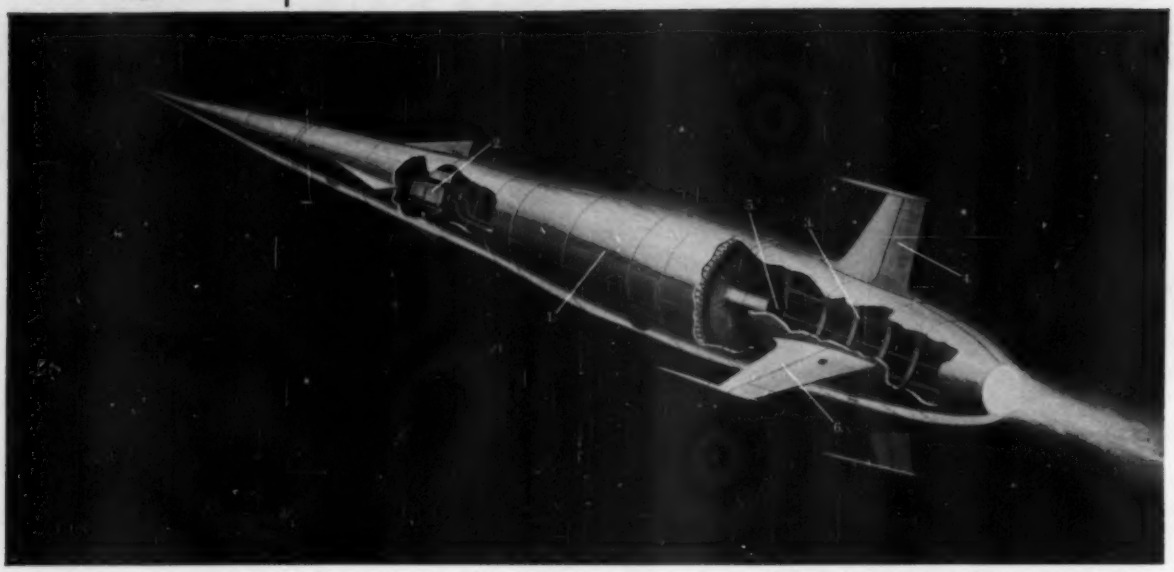

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Let's consider one of these, magnesium's high specific heat and its relationship to missiles. This can mean lower temperatures for given flight conditions. As a result magnesium can be used under very severe flight conditions for short time applications. (See Fig. 2.) This permits the use of magnesium in high speed missiles which are exposed to heat generating atmosphere for only a matter of a few seconds. With magnesium acting as a heat sink it can result in reducing environmental temperature for electronic instruments.

Magnesium offers other thermal properties that are of value in aircraft and missile design. For example, the thermal diffusivity of magnesium-thorium alloys $\left\{\frac{\text{Thermal conductivity}}{\text{Specific heat x density}}\right\}$ is high and remains fairly constant over a large temperature spread. Between 68° and 900°F. the thermal diffusivity of these alloys is in the range of 0.57 and 0.75 cm.²/sec. (2.2 and 2.9 ft.²/hr.)

For more complete data send for Bulletin 141-187 "Magnesium Alloys for Elevated Temperature Use." Contact your nearest Dow Sales Office or write to THE DOW CHEMICAL COMPANY, Midland, Michigan, Department 1300X6-22.

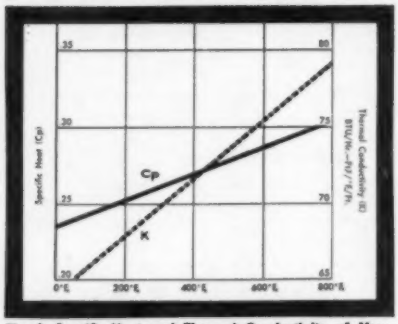

Fig. 1. Specific Heat and Thermal Conductivity of Magnesium-Thorium alloys.

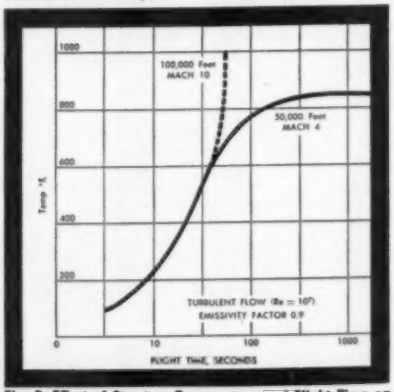

Fig. 2. Effect of Structure Temperature and Flight Time on Mg-Th Sheet Alloys at Mach 4 and 50,000 Feet and Mach 10 and 100,000 Feet.

THE DOW CHEMICAL COMPANY • MIDLAND, MICHIGAN

Our National Space Program

It has been just about 21 months since the Soviet Union signaled the dawn of the space age with the successful orbiting of Sputnik I. It has been just about nine months since the United States created the National Aeronautics and Space Administration as the agency charged with organizing and operating a national space exploration and research program. In this special space research issue AVIATION WEEK is detailing the basic space research program developed by the NASA and the organizational methods and procurement techniques by which it hopes to accomplish its goals during the next decade.

These facts are contained in a special 36-page insert beginning on p. 119 entitled "The Next Decade in Space." It was compiled by a special AVIATION WEEK editorial task force headed by Space Technology editor Evert Clark, Avionics Editor Philip J. Klass and Engineering Editor J. S. Butz, Jr.

NASA faced a formidable task when it was created by legislation during the 85th Congress. At that time the United States had no truly national space program although several scattered efforts at space exploration including Vanguard and Explorer had appeared in an uncoordinated fashion. At that time the Soviet successes with the first three Sputniks put heavy pressure on NASA to retrieve U.S. prestige in this important scientific area.

Three-Fold Task

It is still far too early to expect any major achievements in this area from NASA. The task of this agency in this initial nine-month period has been three-fold:

- **First, to organize** all of the existing space research and development facilities and programs already existing in the old National Advisory Committee for Aeronautics, the USAF Air Research and Development Command, the Navy's office of Naval Research and the Army's Jet Propulsion Laboratory and Ballistic Missile Agency into a truly national space exploration program.
- **Second, to lay the basic** research foundation for this program on which the specific development programs of the future could be soundly based. NASA has done a remarkable job in outlining a sound, long range scientific research program in the short time available. If pursued with the same vigor and foresight that has gone into its organization this program should yield fruitful results in the decade ahead.
- **Third, to develop** specific short range programs aimed at making the initial, scientifically fruitful probes into space. Two solid programs have already emerged in this area—Project Mercury to put a manned capsule into orbit and recover it and the space booster program aimed at providing basic power for the space vehicles of the next decade. In both these programs, NASA has made maximum use of the technology and research already begun by industry, the military services and the scientific community.

In moving rapidly toward these goals, NASA has been aided immeasurably by the strong support afforded by key groups in the Congress. The fine work of the House select committee headed by Rep. John McCormack (D.-Mass.) in the 85th Congress in drafting and passing the basic NASA legislation has been followed in the 86th Congress by equally sound and helpful work of the NASA authorization subcommittee of the Senate Committee on Aeronautical and Space Sciences headed by Sen. John Stennis (D.-Miss.) and his professional staff headed by Max Lehrer. The hearings held by this group earlier this year on the NASA programs, long range plans and scientific objectives were an important contribution to both legislative and public understanding of this vital effort. The committee's 678-page report on these hearings published by the Government Printing Office affords valuable supplementary details in specific areas.

Keith Glennan, NASA administrator, and his deputy, Dr. Hugh L. Dryden, have been extremely candid and realistic in their discussions before the legislators on the cost and timing of the proposed NASA programs. They have promised no quick spectacular achievements at economy bargain basement prices.

A sound, consistent and fruitful national space exploration program will require considerable investment of money, scientific talent and industrial technology. Although the Fiscal 1960 NASA appropriation will be about $485 million, this is only an ante for the large stakes involved in space technology leadership for the future. As the NASA program expands and gains momentum it will require annual budgets ranging up to $2 billion within the next few years, according to NASA Administrator Glennan. If the American people are to consistently support a program of this magnitude, and we believe they should, they must thoroughly understand the goals sought, the time and effort required for reasonable prospects of success and the ultimate value of these achievements.

Space and Humanity

Dr. Dryden has given an indication of what space exploration and research can eventually achieve for humanity:

"Through advance in these sciences we will gain a deeper understanding of the universe in which we live, including our earth and nearby space, the moon and planets, interplanetary space and distant galaxies. This deeper understanding and knowledge will bring the power to predict, to direct and to control the forces of nature and our own destiny."

Looking back to the days of Sputnik I, it is apparent that the United States has abandoned its earlier indifference to space exploration, recovered from the panic induced by spectacular Soviet successes, and has now laid the foundation of a sound long range national space program.

Ensuring the success of this space program poses a formidable challenge to the nation's ability to effectively channel its resources and capabilities into a sustained peacetime endeavor. But meet this challenge we must, if we are to retain our leadership of the free world and discharge our responsibility to humanity.

—Robert Hotz

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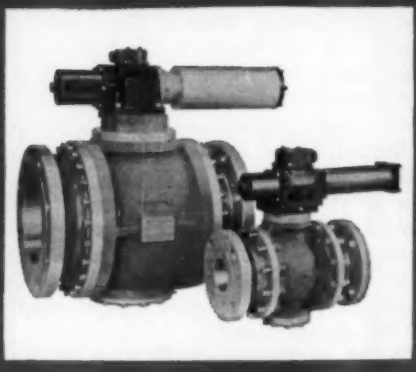

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CIRCLE NO. 70 READER SERVICE CARD

FLO• BALL

WHO'S WHERE

In the Front Office

W. H. Yahn, a vice president, North American Aviation, Inc., and general manager of the Columbus, Ohio, Division. Also: **Richard D. Walker,** assistant general manager at Columbus. **George A. Whiteside** succeeds Mr. Walker as assistant to the general manager in charge of the A3J program.

Warren E. Kraemer, first vice president and deputy to the president, Scandinavian Airlines System, Inc. Mr. Kraemer continues as vice-president-traffic and sales.

Lear, Inc., Santa Monica, Calif., has elected the following company officers to the board of directors: **James L. Anast, Roy J. Benecchi, Barney M. Giles, Philip E. Golde, K. Robert Hahn,** and **Andrew F. Haiduck.**

Eric Lidow, president, and **Dr. Angelo Gallina,** managing director, International Rectifier Corp. Italiana, S.P.A., Milan, Italy, newly formed subsidiary of International Rectifier Corp., El Segundo, Calif.

Glen B. Eastburn, a vice president, New York Airways, Inc.

Arthur J. Briggs, vice-president, Continental-Diamond Fiber Corp., a subsidiary of the Budd Co., Newark, Del.

Jay W. Schnackel, vice president, Remington Rand Division of Sperry Rand Corp., New York, N. Y.

P. B. Harwood, a senior vice president, and **E. B. Fitzgerald,** vice president-engineering, Cutler-Hammer, Inc., Milwaukee, Wis.

Dr. B. Wolfframm, vice president and technical adviser, Magnetic Research Corp., Hawthorne, Calif. Also: **W. E. Brown,** general sales manager; **A. L. Scharff,** manufacturing manager; **H. F. Eckerle,** engineering manager; **R. F. Cook,** comptroller.

Frank A. Parker, Assistant Director of Defense Research and Engineering for Undersea Warfare, Department of Defense, Washington, D. C.

Carroll L. Zimmerman, formerly Strategic Air Command's chief scientist, now director of the Operations Analysis Office, United State Air Force Headquarters, Washington, D. C.

Honors and Elections

Dr. A. W. Wortham, manager of the Quality Assurance Department of the Semiconductor-Components Division of Texas Instruments, Inc., has been elected an executive director of the American Society for Quality Control.

H. E. Weihmiller, of Republic Aviation Corp.'s Scientific Research Staff, has been appointed chairman of the National Astronautics & Space Exploration Committee of the American Astronautical Society. **Robert P. Haviland,** of General Electric's Missile & Space Vehicle Department, has been appointed chairman of the Society's International Astronautics & Space Exploration Committee.

William A. M. Burden, New York financier and aviation consultant, has been elected chairman of the Board of Trustees of the Institute for Defense Analyses, Washington, D. C.

(Continued on page 256)

INDUSTRY OBSERVER

The following column was written by AVIATION WEEK *editors covering the 23rd International Aeronautical Salon at Le Bourget Airport near Paris last week*

► Republic Aviation, Sud Aviation and General Electric are studying a special executive version of the Caravelle for General Electric to be powered by the company's aft-fan CJ805 turbojets. Basic layout is being done by Sud, detailed study of the engine installation by Republic.

► Piaggio and Co. is negotiating with the Italian government for the sale of about a dozen of its P.166 transports as replacements for Beech C-45s now in service as liaison and communication airplanes.

► Propeller shafts on the Dornier 29 STOL research aircraft rotate downward to produce a thrust vector in a lifting direction to improve the short takeoff and landing performance of the plane. Three will be built, financed by the German air ministry, and developed jointly by Dornier and the German Aeronautical Research Agency.

► Bristol Orpheus 803 engines are now being delivered with a thrust rating of 5,000 lb. and steel first-stage compressor blades. In-flight troubles with the first-stage aluminum blades of the earlier engines installed in Fiat G.91 lightweight strike fighter resulted in the change. Orpheus, rated at 9,000 lb. thrust, is in development stage now.

► First operational squadron of English Electric P.1B fighters is expected to join the Royal Air Force by the end of this year. Time gap from first flight to service use will then be two and one-half years. All 20 preproduction P.1Bs are now flying, and the P.11 trainer version, which hit Mach 1.3 on its first flight, is now operating consistently at Mach 2.

► First de Havilland-built General Electric T58 engine, designated the Gnome by the British company, made its first run June 5. Company's second production turboshaft engine was shown at the Paris salon.

► Observers of the bitter battle for airline equipment sales were quick to comment that Sud Aviation's Caravelle at the display was closed and locked to the crowd, while the two Russian transports had long lines waiting to enter and be guided through the planes.

► SEPR auxiliary rocket powerplant for the Dassault Mirage 3 is now in production by Hispano-Suiza. Single-chamber engine produces thrust in two steps: 1,660 lb. and 3,300 lb.

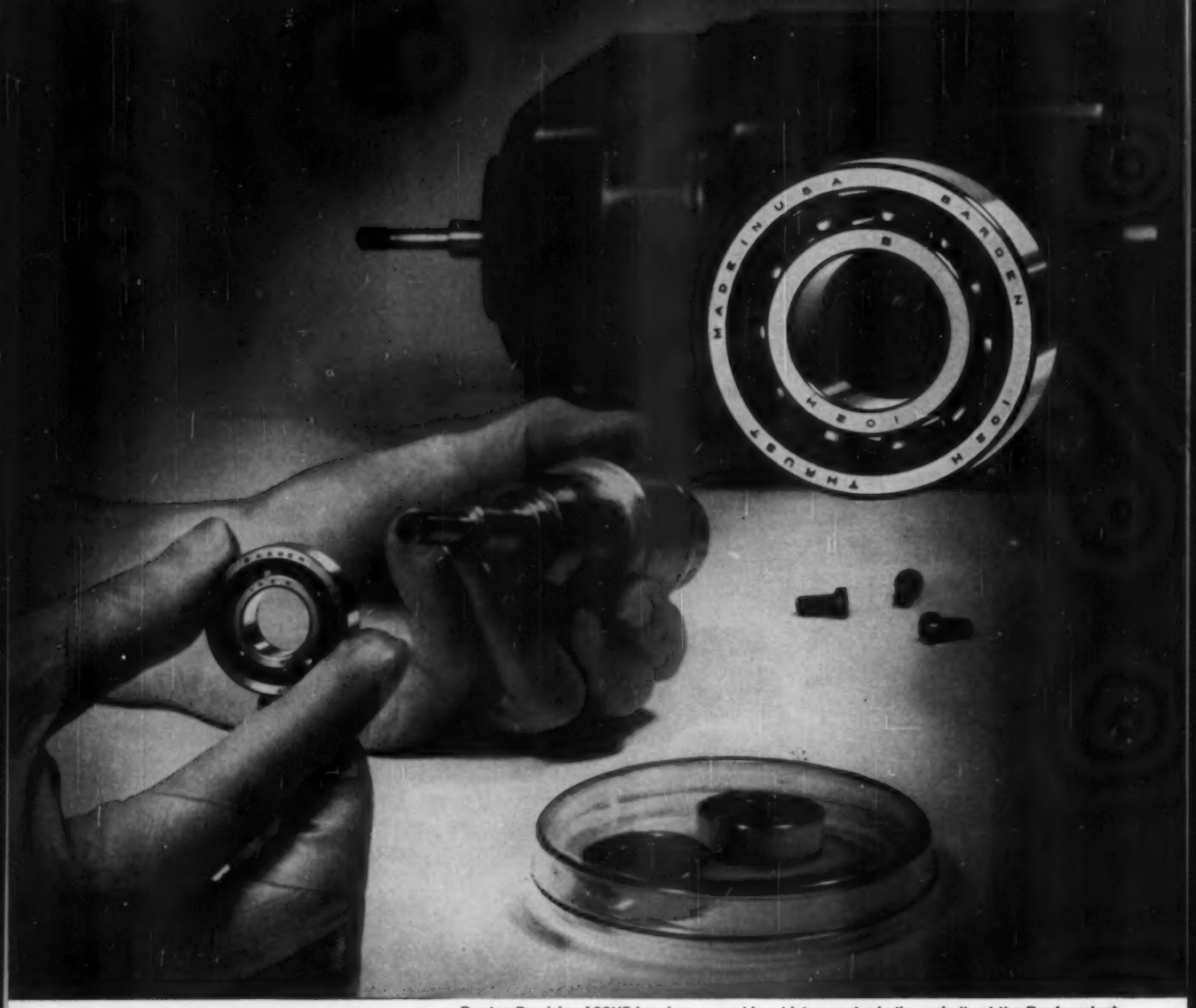
► Bofors Bantam is latest entry in anti-tank missile field. The tiny Swedish missile is wire-guided, weighs only 13.2 lb. per round. Missile is still undergoing trials, is expected to be ready for service use by 1960. Sweden has been a good customer for the Nord SS-10 missiles in past years.

► Workmanship on the Russian Il-18 transport was better than that of most airplanes in the salon, according to observers. Only place where any low-quality work showed was in the layup of the glass fiber weather radome.

► Price of Max Holste Bastan-powered Super Broussard has been set at $182,000. With Lycoming T53s installed, price will be $216,000. No price is given for installation of Armstrong Siddeley P.182 turboprops.

► Antonov An-4 (NATO code Camp) twin turboprop transport is in widespread service with the Red Air Force transport service. Earlier reports that the prototype An-4 that flew at the 1956 Tushino air show was never put into production were disproved by the number of An-4s now spotted leaving and arriving at Soviet airfields on transport duty. For military duty the An-4 is painted a light gray with a large red star on its high tail. Rear gun turret has been removed in production versions.

► Red Air Force transport service is now using a military version of the Il-14M transport designed by Ilyushin and now in widespread civil use with Aeroflot. Military Il-14M has seven cabin windows instead of the six on airline versions and is painted with a heat-reflecting white paint.



Barden Precision 102H5 bearing as used in a high speed grinding spindle at the Barden plant

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Fringecount Micrometer, an ultra-precision interferometer, is used by Barden for the absolute measurement of dimensional masters to one millionth of an inch. This basic reference gage provides the ultimate in quality control instrumentation, assuring consistent accuracy of Barden Precision ball bearings.

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CIRCLE NO. 72 READER SERVICE CARD

Washington Roundup

Berlin Corridor Flights

Top Air Force officials would prefer to continue sending high altitude flights through the Berlin corridor despite Soviet opposition and U. S. State Department's decision to abandon the flights, at least during the foreign ministers' conference at Geneva in order not to increase East-West tensions. Maj. Gen. Gabriel Disoway, deputy commander of U. S. Air Force in Europe, who agrees that from a diplomatic standpoint State Department made the right decision, says he would like to see high altitude flights continued to establish the principle of flights above the 10,000 ft. limit the Soviets want to impose on USAF flights through the East German corridor. It also would permit efficient utilization of aircraft such as the Lockheed C-130 turboprop transport.

Nuclear Plane Decision

Watch for a final decision early in July on the USAF program to build two nuclear powered aircraft prototypes. After the death of Deputy Defense Secretary Donald Quarles (AW May 18, p. 39), responsibility for the program shifted to Dr. Herbert York, Defense Department director of research and engineering. Dr. York and his staff have been engaged in getting a comprehensive briefing on the subject from USAF, Atomic Energy Commission and the engine and airframe contractors, General Electric and Convair. Dr. York is expected to report his findings to the Joint Congressional Committee by the end of June, with a decision promised shortly.

Airport Aid Bill

After reluctant approval by the Senate, a two-year "stop gap" extension of the federal airport aid program at the present level of $63 million a year was sent to the White House.

In February, the Senate approved a $465 million four-year airport aid program (AW Feb. 16, p. 39). This not only met opposition in the House, which reduced the program to $297 million (AW Mar. 2, p. 25), but also faced a presidential veto. The expressed attitude of the Senate majority in accepting the $126 million program was "take this to keep the program going—until we can get something better."

The measure sent to the White House leaves the use of federal funds for construction of terminal building discretionary with the Federal Aviation Agency administrator, with these exceptions in which federal expenditures are explicitly prohibited: parking lots, bars, and certain federal government facilities such as post offices and immigration facilities.

Materiel Post Nomination

USAF Maj. Gen. Mark E. Bradley, Jr., has been nominated by the White House for promotion to lieutenant general and appointment as deputy chief of staff for materiel. Maj. Gen. William O. Senter, formerly director of procurement and production at Air Materiel Command, will be his deputy. Bradley now is acting chief and was deputy to Lt. Gen. Clarence S. Irvine.

In other USAF command changes, Maj. Gen. J. E. Smart moves from assistant vice chief of staff to command of the 12th Air Force, Tactical Air Command, and will be replaced by Maj. Gen. R. M. Montgomery, now commander of Strategic Air Command's 3rd Air Division; Brig. Gen. R. E. Greer, deputy assistant chief of staff for guided missiles will move up to assistant chief; Brig. Gen. J. Stanley Holtner, who has been nominated for another star, becomes military assistant to Defense Research and Engineering Director Herbert York.

Eisenhower on Contracting

President Eisenhower was asked at his press conference last week if he thought "that improper pressures are exerted when former high ranking officers take jobs with companies which solicit defense contracts." The questioner prefaced his inquiry with the observation that "a congressional committee, investigating what some people have called a munitions lobby, is looking into the employment," of such officers.

"Well, really, I don't know anything about it," the President replied. "No one has certainly ever tried to do it with me, and anyway, I don't have anything to do with the contracting business.

"But, I think there is justification for the Congress informing itself as to exactly what connections, not necessarily with foreign—with former officers of the government—but with the business—with the contracting officers of the present government. I think it's all right to look into these things because we must be careful and I think anyone that is acting in good faith would have nothing to fear of such an investigation."

Boeing Defends Ad

Boeing Airplane Co. is standing firm in defense of its Bomarc advertisement which appeared in Washington, D. C., newspapers May 27, touching off a flurry of congressional charges that the company was trying to influence an imminent decision on the "mix" of Bomarc and Nike-Hercules in the air defense system.

In a letter to Air Force, and transmitted to the House Armed Services Investigating Subcommittee, Boeing stated:

"The object of the advertisements was to point up Bomarc's cost-effectiveness, its readiness, and the fact that only a small portion of the money alotted for production of the weapon system is spent for in-plant Boeing work. We felt that it was essential not only in our own interest but in the interest of the defense of the U. S. to make known these facts, because much confusion existed as a result of erroneous information being circulated by partisan sources . . ."

The advertisement was published, Boeing continued, "approximately a week following a Western Electric ad on the similar subject of subcontracting. The Western Electric ad featured the point that some 8,000 firms help build Nike sites. Our ad headlined the point that 3,500 firms help build Bomarc. Were our intention to outdo our competitors we could, with justification, have revised our ad to show an equally large subcontracting base, using second and third tier suppliers for the purpose. We did not do this, preferring, as in the other ads, conservative statements intended to recite only the genuine merits of our effort. The facts stated are unassailable."

Air Force reported that the Bomarc ad was paid for out of Boeing profits and not charged against government contracts and that no Air Force officers or official participated in the project in any manner whatever. The security review of the ad was done by the Department of Defense.

—Washington staff

AERIAL VIEW of Paris air show was taken from Dornier 27. Missile park (right center) is dominated by Atlas and Thor-Able.

U.S. Missiles, Planes Dominate Paris Show

French projects, compared with show two years ago, show effect of budget cuts; British make stronger bid.

Paris—First reaction to this 23rd International Aeronautical Salon is one of shock that the French aircraft industry could have fallen so far so fast.

Two years ago technical observers at the salon were tremendously impressed with the parade of French ingenuity in aircraft design and development.

But this year's exposition, like an off-year Farnborough, displayed only the hardy perennials of the French air fleets. There were no brilliant new concepts in weapon system design, no aerodynamic genius shown in sports or business aircraft, no word of a successor or even a successful production run for France's only transport hope, the Caravelle.

The official attitude that the salon was "bigger and better than ever" was in sharp contrast to the privately expressed frustrations of French engineers and technicians who have seen many promising projects dropped during the past two years because of lack of substantial funds.

Hard, driving work by French technicians during the final hours before the salon opened got several prototypes off the ground in time for their first official flights to be announced opening day.

But at mid-week, Dassault's Mirage 4, widely heralded as France's atomic bomber, had just made its first flight after several weeks of making taxi runs up and down the runway at Melun-Villaroche.

Except for this Mach 2 delta-wing prototype, there was little else in prospect to back France's claim to greatness in the air.

This salon has become almost the personal property of the United States Air Force.

The Air Force moved in, bag and baggage, in everything from a little Cessna T-37 trainer to the luxurious Boeing VC-137 executive jet transport. USAF brought the Convair Atlas, Douglas Thor and Martin Mace. It showed space mice and laboratory equipment for space medicine.

The North American X-15 in mock-up form hung over cases of space displays. There was a model of the Martin Titan, the Reaction Motors' XLR99 rocket engine for the X-15, and a Boeing Bomarc.

Biggest attention getters were the three huge ballistic missiles erected outside in the static display: USAF's Convair Atlas and Douglas Thor-Able; and the Army's Chrysler Redstone. Serviced and erected by snappily moving crews wearing freshly lacquered helmets and with knife-sharp uniform creases, these big missiles dominated the show and much of the feeling about it. Long lines of spectators waited to walk through the Atlas, looked upward at the nose probe of the Thor-Able, wondered at the Discoverer satellite nose section and worried about the Army Redstone now deployed in Europe.

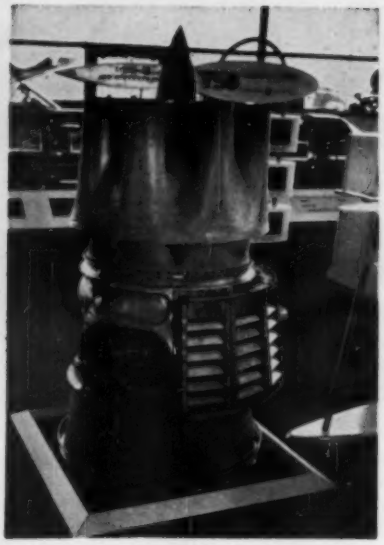
It was ironic that these missiles and the display of USAF strength should come to the salon at a time when the relations between France and the United States were strained by President

French Air Show Coverage

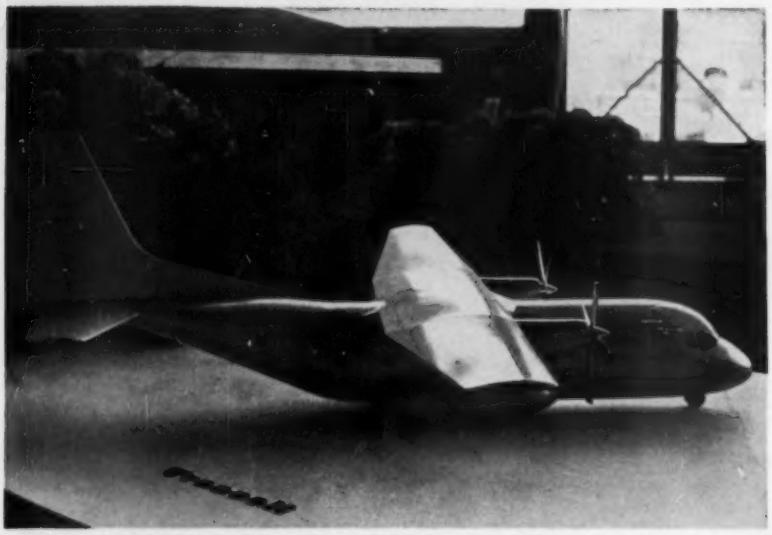
Coverage of the 23rd International Aeronautical Salon at Paris last week was provided by Aviation Week staff members David A. Anderton and Robert Stanfield, assisted by Robert Farrell of the Paris bureau of McGraw-Hill World News, and Russell Melcher, who took the photographs.

DASSAULT Etendard 4M (above) is armed with Sidewinders (center) and Nord 5103 missiles (left). Dassault Communaute 10-seat liaison and transport plane (below) is armed with two rocket pods and Nord SS-10. Gun pack for 30-mm. cannon is on ground.

SECOND PROTOTYPE of Sud Aviation 3200 heavy helicopter (below) was on static display. First prototype flew just before show opened.



BOLKOW helicopter trainer (left) was one of smallest aircraft on display. Rotor has single blade and counterweight. Cascades on General Electric thrust reverser and silencer unit (right) are experimental units but typical. They give about 55% reverse thrust.



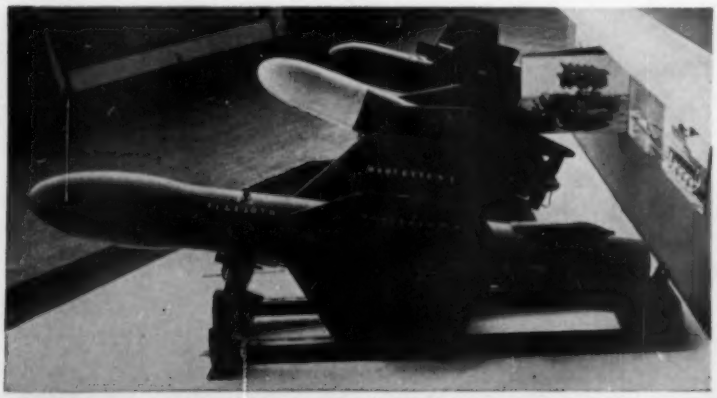
TRANSALL C. 160 transport resembles Lockheed C-130, is being developed by Nord Aviation (France) and Weser Flugzeugbau, Hamburger Flugzeugbau and Blume (Germany).

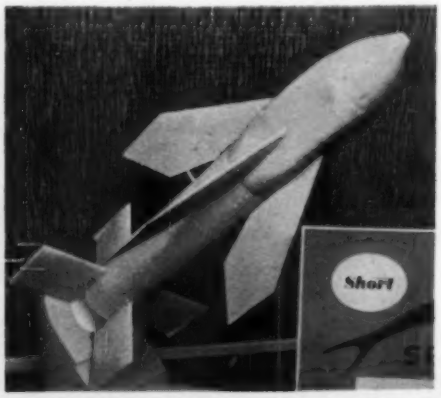
de Gaulle's demand for control over all atomic weapons stationed on French soil. Plans were under way to move out of France all USAF fighter-bomber squadrons, which have been on rotational assignments anyway, but this did not lessen the tension.

In complete contrast to the military might of the United States, the U.S. commercial transports were conspicuous by their absence. Boeing, Convair, Douglas and Lockheed showed models, dioramas, cabin sections and pictures of happy customers riding in jet transports, but no actual airplanes. Pan American World Airways did Boeing's best advertising with its scheduled transatlantic jet service landings at Le Bourget.

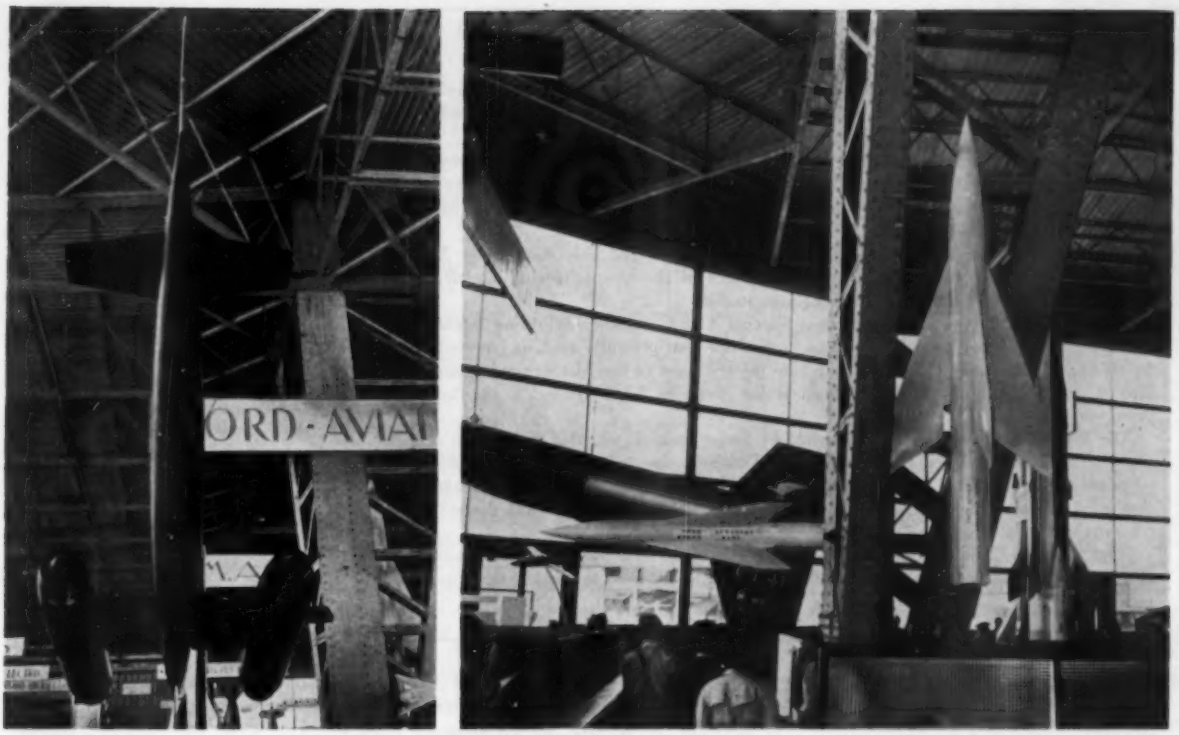
The big Boeing 707-120s attracted lots of attention from the crowd.

Boeing, on a stand adjacent to Douglas, displayed gamesmanship with a large sign saying that from Oct. 26 until opening day, 310,000 passengers had





NORD SS-12, latest version of the anti-tank missile family, is at left; SS-11 is behind it and SS-10 is in background. Short Brothers & Harland Seacat (right) is short-range missile intended to replace 40-mm. anti-aircraft cannon on board British navy ships.



NORD CT-41 (left) is recoverable supersonic ramjet drone. Nord 5301 anti-aircraft missile (right in right photo) has same basic configuration as 5103 air-to-air missile (left in right photo). Both use jet exhaust vanes for directional control. Missiles below are, front to rear: four-stage ONERA Mach 7 test vehicle; Matra anti-aircraft missile; USAF Boeing Bomarc; Army Nike Ajax and Nike Hercules.

flown in the Boeing 707. Additional signs, in increments of the daily load of 3,500 people, were ready on the Boeing stand for insertion each day.

But that was about the contribution, and one French engineer said, "why do you let the Russians show the airliners while you show the missiles?"

Russia's contribution was a pair of Aeroflot's jet-age transports: Tupolev's Tu-104B and Ilyushin's Il-18. The Tu-104B still looks like a British railways design and was in crude contrast to the sophisticated workmanship and impeccable cleanliness of the Ilyushin turboprop. The vice president of one big U. S. company said, after having gone through the Il-18 with a critical eye: "If that came out of our factory, we'd be very proud of it."

Aeroflot crews, uniformed badly in baggy gray, spoke French or English and were on hand to explain the interior layouts.

The strongest showing among the French companies was by Nord Aviation, probably the world's leading quantity producer of missiles.

The company has three specialties, now that the Griffon turbo-ramjet airplane has reached the end of the line: heavy transports, target drones and guided missiles.

Nord showed a model of the Transall C.160, a twin turboprop cargo transport being developed jointly by Nord and

Dassault Defends Mirage 3

Paris—Stung by an alleged "whispering campaign" against its Mirage 3 interceptor-fighter, Dassault broke its traditional silence in a public blast against the Lockheed F-104, chief competitor of the Mirage for export sales.

In a report entitled "There Are Two Mirage Threes," the French company termed "erroneous" the "wide-spread" opinion according to which West Germany, after studying and comparing the Mirage 3 and F-104, chose the latter because its performance was "clearly superior."

German evaluation teams, the Dassault release noted, tested only the Mirage 3 prototype, not the production version. Performance of the two delta-wing aircraft, the release emphasized, are far from being comparable.

The Mirage prototype is powered by a Snecma Atar G turbojet delivering 8,800 lb. thrust. The Mirage production version, of which four presently exist, is powered by an Atar 9 with about 13,000 lb. thrust. Wing thickness of the Mirage production aircraft, the release also noted, has been scaled down to 3.5% from 5% on the prototype.

The French company's statement, signed by Serge Dassault, chief of the builder's flight test division and son of owner Marcel Dassault, also noted that the "F-104 proposed to the Germans is a new aircraft whose radar equipment is different from that used in the United States." The release claimed that such an aircraft doesn't yet exist and won't fly for another year.

"Our Mirage 3," the release read, "does exist and should have nothing to fear from this fictitious competitor for which our German friends will have to pay the development costs."

three German companies: Weser, Hamburger and Blume. Powerplants are Rolls-Royce Tynes and the gross weight is in the 90,000-lb. bracket.

Design and layout of the C-160 was greatly influenced by the Lockheed C-130, and some of the engineers involved in the project quietly admit this.

Nord also showed two new missiles:

• **Nord 5301,** an anti-aircraft rocket with a range of about 10 mi., claimed to be effective against aircraft traveling at speeds of Mach 1.2. The missile has a two-stage solid propellant system, and depends on jet vane control for steering like other missiles in the Nord line. After 24-sec. burning time, the missile's maximum speed is about Mach 1.8. Weight of the warhead is about 90 lb. Length of the missile is just under 15 ft. and its takeoff weight is 1,050 lb. Configuration is similar to 5103 missile.

• **Nord SS-12,** a tank-busting missile with considerably increased range and destructive power compared with the company's earlier SS-10 and SS-11. Outstanding feature of the SS-12 is the control system, where steering of the missile is passed from a pilot at the launching point to a pilot farther forward. Control comes from electrical impulse passed through trailing wires.

Final exhibit on the Nord stand was the CT-41, a twin-ramjet powered target drone with supersonic performance and a parachute recovery system for re-use of the vehicle. The drone weighs 2,760 lb. normally, and 5,500 lb. at launching, including two solid-propellant booster rockets. Over-all length of the CT-41 is 32.1 ft., and total span is 12.2 ft. The ramjet engines are about 30-in. in diameter.

Dassault prominently displayed the two-seat trainer version of the Mirage, designated the Mirage 3B. Shown on the stand armed with Nord 5103 missiles and a Dassault-developed unguided-rocket pod, the Mirage now bears little resemblance to the early versions of the plane.

Major changes include a reduction in wing thickness to 3½%, which is probably the thinnest wing built in Europe.

Greatest change in attitude toward the Paris salon was shown by the British aircraft industry. In 1957 its small effort at the show had been criticized in the British aeronautical and daily press. This year at Le Bourget, British participation was very strong in all lines from complete aircraft and missile systems down to aircraft hardware and raw materials.

Prominent among the British displays were the stands of Bristol Siddeley engines and Rolls-Royce, Ltd. Both were showing a wide range of types and ratings of powerplants and both were selling hard. Bristol Siddeley made the first official announcement of the BE 53 engine which, by its designation, shows it to be a complete Bristol design developed before the recent merger of the companies. The BE 53 is rated somewhere around 14,000 lb. thrust and should be running "soon," according to the company. It is supposed to have a higher thrust/weight ratio than any other existing turbojet.

Specific fuel consumptions are being spoken of in awed tones by Bristol people, but are generally believed to be a little better than turbofan consumptions now being quoted by General Electric for its CJ805-23 engine. Perhaps 0.5 is a reasonable figure to assign to the BE 53.

The Italian aircraft industry took a complete stand for itself for the first time, showing a variety of products, accessories and models of airplane projects. Chief among these was a proposed freighter with two podded turboprop engines proposed by Societa Aerfer.

Sweden's Svenska Flygmotor showed its VR3 liquid propellant rocket engine designed either for auxiliary power for manned aircraft or as the main powerplant for missiles. Fuel is 85-1/0 hydrogen peroxide and kerosene, and thrust rating is 5,700 lb. at 19,000 ft. Variation of thrust is controllable between 40 and 100% of thrust. The de Havilland Spectre is a comparable engine.

The company also had a ramjet engine, the RR2, on its stand, shown both as a complete powerplant and as a nose "bullet" complete with turbopump assembly and fuel injectors. Diffuser nose spike was of the Oswatitsch double-shock type.

A quartet of Estampes biplanes from the French civilian pilot training center at St. Yan gave an acrobatic display that took many spectators back to the time when an air show could be given in front of a small audience and didn't require a 10-mi. cube of sky. The airplanes started in a normal flypast in line abreast and then, beginning with the right-hand man, spun off the top to stream out in trail and began their demonstrations. Three flew formations throughout and the fourth man did individual exhibitions between the group maneuvers. The conclusion was a harrowing pair of inverted passes at the field, first by the soloist and then by the trio.

New business types included:

• **Lavender-colored Super Wassmer,** a four-place touring aircraft developed by the French Wassmer company. The aircraft is powered by a single 180-hp. Lycoming engine, and cruises at 165 mph. Span is 32.8 ft.; gross weight is 2,650 lb.

• **Red-and-cream** M222 Flamingo, an Austrian entry in the field, developed by Simmering-Graz-Pauker S.A. of Vienna. The airplane is a light twin-engined layout powered by a pair of 150-hp. Lycoming engines. Normal gross weight is 3,400 lb. Maximum speed is 186 mph., and wingspan is 36.1 ft.

• **Morane-Saulnier** twin-place MS 880 Rallye sport plane powered by 90 hp. Continental. Constructed entirely of metal, the aircraft features tricycle landing gear and dual controls. Empty weight is 77 lb., gross weight about 1,280 lb. Maximum speed is rated at 115 kt., cruising speed at 99 kt. Wing span is 28 ft.

Soviet Yak-25s Threaten NATO Border

By Cecil Brownlow

Ramstein AFB, Germany—Soviet Union is beginning to push Yak-25 Flashlight all-weather interceptors into the nations of eastern Europe to face tactical aircraft of the North Atlantic Treaty Organization.

The Flashlight, which may be equipped with long-range air-to-air missiles, could present a particularly serious threat to NATO forward-echelon aircraft operating from bases such as Ramstein which already lies within a few moments of Soviet 100-700-mi. ballistic missiles sites and 15 min. by Il-28 bomber from satellite airfields.

Conversely, frontier areas of Soviet military defenses in the east European satellites lie within seven minutes' range of the Convair F-102 which finally is being brought into one U.S. fighter wing here to replace the venerable North American F-86D Sabrejet. The F-102s will be fitted with Hughes GAR-1 and GAR-11 air-to-air missiles. Over-all the Soviets have approximately 20,000 combat aircraft, 3,000 of these in eastern Europe, that could be thrown against NATO when, and if, a hot war should develop.

To meet this threat in central Europe where probably the largest Western military targets in Europe are located, the NATO command has committed to it approximately 1,500 aircraft representing the United States, Canada, France and the infant but growing West German air forces. Such a disparity in forces makes use of atomic weapons by NATO almost automatic, and virtually eliminates any chance of a localized conventional war in Europe.

Headquarters for NATO's aerial defense of central Europe is located at Ramstein, a large and busy U. S. Air Force base approximately 35 mi. west of the Rhine and about 75 mi. southwest of Frankfurt. Its organizational command, the Fourth Allied Tactical Air Force, consists primarily of a headquarters staff, with the combat units it needs to be effective slipping from national to NATO responsibility in a theoretically smooth, no-time-lost transition only if and when war actually comes. Present commander of the Fourth is Gen. Frank Everest who also wears the hat of commander of U.S. Air Forces in Europe.

To carry out its initial mission of trying to hold the line as long as possible against Communist ground and air operations until help can be summoned from abroad, the Fourth—assuming that the transfer of national units to NATO command is made without hitch—has in its inventory from U.S. commitments the Douglas RB-66 reconnaissance bomber, North American F-86D, F-100D-F, Convair F-102, the McDonnell RF-101 and the 38th Tactical Missile Wing now converting from the air-breathing Martin Matador to the more sophisticated Mace; from France wings of Republic RF-84F and F-84F aircraft, the F-86K and the Mystere 4A; from Canada the Sabre 6 and the CF-100, and from West Germany F-84F units. Army Nike Ajax and Hercules units also are beginning to come into the inventory and will be under the operational control of Gen. Everest.

Aside from the Yak-25, the Il-28, the Badger twin-jet bomber and the ballistic missile threat, the Fourth's known adversaries already located in the satellite nations include the aging Il-10 piston engine ground attack bombers; the MiG-15 with a range to hit West German targets to areas west of Metz, and the MiG-17 and MiG-19 which can cover tactical and strategic sites in England and France.

Targets in Germany

The Il-28, operating from airfields in western Russia, can attack all targets in Germany, the Lowlands, France and England and, despite the appearance of ballistic missiles in numbers, is still regarded as Russian's major air atomic threat to Europe. The Il-28 now is being replaced in first-line bomber units by the supersonic Blowlamp.

The ballistic missiles, of course, can reach their targets whether located in western Russia or within the satellite complex. At least some of these missiles are believed to be located aboard railway flatcars ready for launch, giving them a much wider range of mobility than the 1,500-mi. range USAF-Douglas Thor now stationed in England.

Operationally, units scheduled for the Fourth Allied Tactical Air Force in time of war have a total of some 50,000 people operating from 25 air fields and an integrated network of radar stations that peer from wooded West German mountainsides into the satellite areas for distances of well over 200 mi.

At present, the breakdown of staff personnel for the Fourth is 50% American, 30% French and 20% Canadian. As the West German air force expands to its program level of 1,000 jet planes by the early 1960s, the ratio is scheduled to gradually evolve to a level of 40% United States, 24% French, 20% German and 16% Canadian.

The Fourth, in meeting a Soviet challenge from the air in western Europe, would be joined by the Second Allied Tactical Air Force in the northern part of West Germany, the Fifth in Italy and the Sixth in Greece. Its programed target area extends across Czechoslovakia, Poland and East Ger-

Soviet Space Plans Slipping?

Moscow—Soviet timetable for putting a manned space capsule into orbit and recovering it has apparently slipped considerably due to unforeseen development problems but is still a high priority program.

This is the impression gathered by U. S. delegates to the 52nd general conference of the Federation Aeronautique Internationale from several weeks of informal conversations with top Soviet space medicine researchers.

Soviet technicians were generally tight lipped about their man-in-space program in talking with Western delegates. Some even refused to discuss Russian material that had already been published internationally in their International Geophysical Year papers. But the following points emerged from these informal discussions:

- **Soviets are already testing super-oxide systems for manned space capsule environment. In contrast, the U. S. only recently let initial contracts for experimental development of this type system.**
- **Soviets have put a variety of primates, including chimpanzees, into space and recovered some of them successfully. These apparently were straight ballistic missile type shots with no indication that any of these life-containing capsules had been orbited or recovered from orbit.**
- **Soviets have selected four astronauts for their first manned space capsule program according to the same general criteria used in picking the NASA Project Mercury astronauts. Soviet astronauts are all senior aircraft test pilots with Hero of the Soviet Union awards and are generally older than the U. S. Mercury pilots. One of the four Soviet astronauts was recently killed in an "experimental accident" but no indication was given as to whether this was during aircraft testing or as part of the space program.**
- **Institute of Astro-biology has been established at Alma-Alta where extensive observatory facilities are also available in the Altai mountains. Much of the Soviet belief in the existence of intelligent life on Mars is the result of this institute's work.**

many and into parts of Hungary and the Soviet mainland.

Essentially its wartime tasks in attempting to slow the Soviet advance as laid down by NATO and in the order of their priority include:

- **Support of external** and assigned strike forces.
- **Execution of an atomic** air offensive.
- **Creation and maintenance** of a favorable air situation.
- **Provision for essential** air defense.
- **Delay of Soviet** ground advance.
- **Disruption of Soviet** logistics.
- **Support of NATO** land and naval operations.

In actual operation, its most immediate task would be the destruction of Communist air and atomic striking forces with an offense designed around the atomic forces of the United States and backed by the conventional units of the Canadians, French and West Germans.

The Fourth, in an effort to cut through the difficulties of language differences, varying operational concepts and different types of often obsolescent equipment, plans and executes an almost continuous round of maneuvers and exercises, sometimes utilizing practically all the forces that would be assigned to it in time of war despite the fact that these units still remain under national control.

Objective of Exercises

Exercises planned for 1959 range in length from one to seven days and in scope from problems on paper to full-scale operational maneuvers. Objectives include:

- **Improving the effectiveness** of the atomic strike force and over-all offensive and defensive posture.
- **Increasing exchange** of information, tactics and data between units of the four nationalities involved.
- **Improving combat** and reconnaissance procedures employed by the national commands.
- **Testing emergency defense** plans to try to assure that they are realistic and within the capabilities of the forces involved.

Nerve center of the Fourth Allied Tactical Air Force—and one which plays a vital day-to-day peacetime role in the operations of USAFE—lies in three underground corridors of reinforced concrete pushed into a red sandstone hill in West Germany which houses USAFE's advanced headquarters combat operations center.

The center, whose home was originally dug by German Wehrmacht engineers, is the correlating point for the radar picket stations peering into the air activity of the eastern satellites and would serve as Gen. Everest's operational headquarters in event of war.

Here movements of friendly aircraft and of Communist aerial activity sighted by radar well inside the Iron Curtain are carefully plotted on a three-story-high transparent vertical board in the center's operations room—friendly planes in white, Communist aircraft in bright orange.

On the board, a jagged and heavy red line defines the border between East and West Germany and behind that a dotted red line outlines the borders of a USAFE air identification zone. The zone, which averages 30 mi. in depth from the border, is kept virtually clear of all Allied aircraft so that immediate identification can be made of planes operating in its confines.

If, on the center's vertical control board, an orange line nudges into the ADIZ—and often if it only pushes its way onto the heavy red line denoting the border—the order goes out to scramble a unit of fighter planes. Some fighters are always standing by with pilots aboard on five minutes' alert, to make positive identification and, if necessary, to warn the Communist plane to turn back into his own territory. The instances of deep penetrations, however, are slight, with Communist radar controllers also keeping close surveillance on traffic and ordering aircraft to turn back when they press too closely against the border.

The orange lines of the board also give an indication of the satellite reaction capability on the rare occasions an Allied aircraft misjudges his position and wanders over the border area.

Other major installations in the center include a tactical weather forecast unit which relays forecasts to the USAFE tactical units at least four times daily and a mono-robot digital computer which electronically works out blind bombing problems in advance.

McElroy Asks Fund Restoration

By Ford Eastman

Washington—Defense Secretary Neil McElroy last week urged the Senate Defense Appropriations Subcommittee to restore nearly all the cuts, and to eliminate most of the increases, the House approved in the Fiscal 1960 defense budget. This would bring the total defense budget about $100 million more than the Administration originally requested.

As passed by the House, the defense bill provides $38.9 billion in appropriations plus $421 million to be derived by transfer from the Defense Department revolving funds, for a total of $39.2 billion in new obligational availability, exclusive of military construction. The President's budget requests called for appropriations of $39.2 billion plus $340 million in transfers for a total of $39.5 billion in new obligational authority.

McElroy has now asked the Senate for $39.3 billion in appropriations, and by accepting the House increase in transfers, a total obligational availability of $39.8 billion.

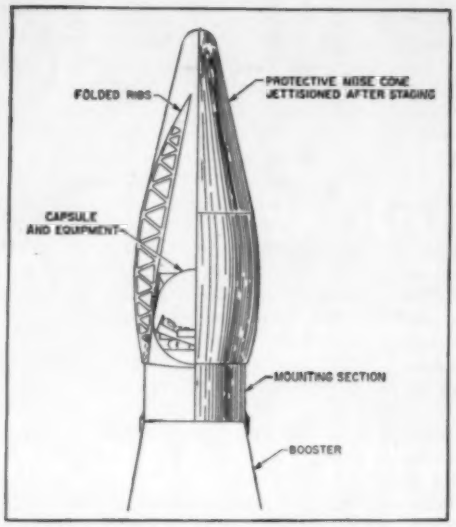
The net reduction of about $400 million in the President's budget requests made by the House is the result of increases totaling $780 million which was more than offset by decreases totaling $1.099 billion and the substitution of $81 million of additional transfer authority in lieu of new appropriations.

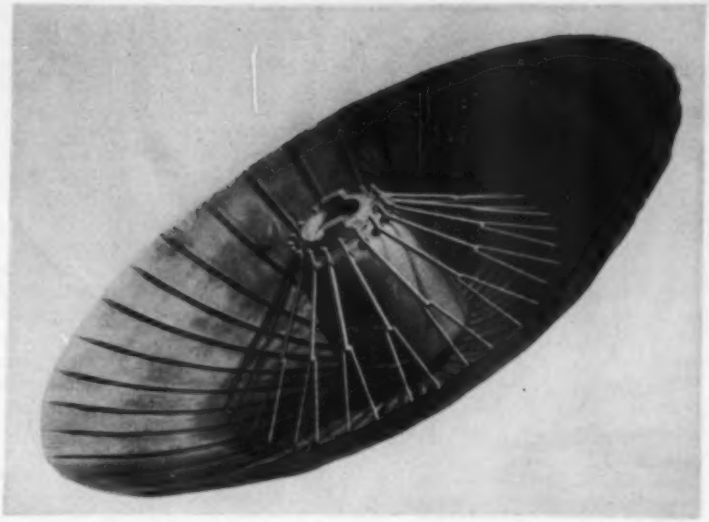
Of the $780 million increases voted by the House, McElroy asked that $505 million be eliminated by the Senate and of the $1.179 billion decrease, the Secretary urged that $1.052 billion be restored. Major House cuts which McElroy asked the Senate to restore in full, or partially, are:

- **All the $260 million** asked for a conventionally powered attack carrier for the Navy.
- **All of the $101 million** requested for the procurement of jet navigation trainers, jet utility aircraft and jet cargo aircraft.
- **$129.9 million of the $162.7 million** cut for procurement of the Air Force Boeing Bomarc area defense missile.
- **All of the $127.5 million** asked for the procurement of the Air Force's Martin Mace surface-to-surface missile.
- **$41.7 million of the $50 million** deleted from Air Force procurement under the radar improvement program.
- **$129.8 million of the $131 million** which the House slashed as a 1% across-the-board reduction in all procurement appropriations.
- **All of the $100 million** cut in contingency funds for "safety-of-flight" modifications.

Here are Defense Department recommendations regarding increases made by the House in the defense appropriations bill:

- **Eliminate the $152 million** added to maintain Army reserve strength at 300,000 and Army National Guard at 400,000.
- **Will accept an additional** $200 million voted for the Nike Zeus anti-missile missile program and/or Army modernization.
- **Will accept $1.3 million** of the $255 million voted to increase the Navy's anti-submarine warfare capability.
- **Eliminate all of the $85 million** extra voted as down payment on eight additional Atlas intercontinental ballistic missile squadrons.
- **Will accept $73.4 million** of the $87 million increase in the Minuteman solid propellant ICBM program.





UMBRELLA-LIKE drag brake satellite (right) proposed by Avco's Everett Research Laboratory, offers less weight, more controllability than fixed-drag satellite shapes. Capsule is in center and nose of umbrella shape faces forward during orbital flight and re-entry. At launch (left) stainless steel ribs and cloth of brake are folded upward around capsule and are protected by nose cone. Man lies supine on couch.

Space Technology

Avco Brake May Cut Satellite Weight

By Evert Clark

Washington—A stainless steel variable-surface drag brake that permits lower weight, more precise landing control and other advantages over fixed-drag satellites has been proposed by Avco Corp.'s Everett Research Laboratory for manned orbital flight and for atmospheric braking on return from more distant flights into space.

The brake is a folding, umbrella-like structure that allows a 20-to-1 variation in drag, offering the possibility of circularizing elliptical orbits and giving a manned satellite a high degree of independence of tracking-control nets.

The brake is an outgrowth of three years of design exercises that projected Avco's work on missile nose cone re-entry techniques. The work was reported by R. W. Detra, A. R. Kantrowitz, F. R. Riddell and P. H. Rose.

Avco-Everett now is doing an analytical study for Air Force on a vehicle drag brake control system for re-entry and recovery from distant space flight.

Use of the drag brake to bring down a one-man satellite in the 2,000-2,500 lb. weight range costs 500 lb. in weight, vs. about 1,100 lb. for a retrorocket system as in Project Mercury.

The Avco brake would consist of a number of .020 in. stainless steel beam ribs, reinforced with cap strips and covered with .001 steel wire woven into a cloth with a 400 x 400 mesh. Porosity of the cloth removes the cool boundary layer air blanketing the surfaces and significantly increases heat transfer on the drag brake. To eliminate this, the skin can be built up of .0005 in. solid steel sheets cut into circumferentially aligned ribbons or shingles, and then sandwiched between two layers of the cloth. The capsule is carried inside the brake itself. At launch, the front surface of the brake, which is the front end of the orbiting vehicle, faces downward and

Manned Satellite Recovery Systems

Basic structure	167 lb.
Inhabitable capsule	133 lb.
Escape system	695 lb.
Environmental equipment	70 lb.
Pilot support	46 lb.
Cockpit	17 lb.
Navigation aids	41 lb.
Communications equipment	212 lb.
Instruments	15 lb.
Recording equipment	24 lb.
Power supply	157 lb.
Programer	9 lb.
Man and suit	210 lb.
Total	1,796 lb.

Comparisons

Retrorocket System		Avco Drag Brake	
Added structure	133 lb.		0 lb.
Berylliun heat shield	398 lb.		0 lb.
Automatic orientation	137 lb.		25.5 lb.
Power	66 lb.		0 lb.
Retrorocket	207 lb.	(drag brake)	425 lb.
Recovery systems	165 lb.	(2nd stage escape)	50 lb.
Total	1,106 lb.		500.5 lb.

Operational Weights

Retrorocket System	Avco Drag Brake
Launch 2,902 lb.	2,297 lb.
Orbital 2,207 lb.	1,527 lb.
Re-entry 1,914 lb.	1,399 lb.

the ribs are folded around it like a closed umbrella and covered with a protective nose cone. Occupant lies supine on a contoured couch similar to that proposed for other manned satellites.

Satellite would be launched into a 105 naut. mi. near-circuit orbit, allowing anything from a two-day orbit in the low drag, or closed, position to emergency recovery in two hours.

The small amount of residual atmosphere at this altitude is enough to orient the vehicle into the air stream even with the drag brake closed. Reentry consists of several phases:

- **Descent from orbital** altitude to the region from which controlled re-entry will be made.
- **Control of drag** according to a preset program for about one-half of an orbit in order to achieve a given velocity vector at a particular point.
- **Fixing of the drag brake** in the open position at the beginning of serious heating. The vehicle then passes through the heating peak of 1,480F at the nose of the umbrella at 270,000 ft. and deceleration peak of 8.2g at 233,000 ft. and reaches terminal velocity just below 200,000 ft. Time above 8g is about 20 sec.
- **Drifting for some 15 min.** at terminal velocity to a landing, which is made at 50 fps. at sea level.

Landing point can be controlled to within plus or minus 150 naut. mi. by varying drag. From a 90 naut. mi. altitude orbit, re-entry can be made in as many as 15 orbits or in less than a single orbit. Using the geometric mean drag brake position, landing point from a position 3,000 naut. mi. away can be varied by plus 2,000 naut. mi. or minus 1,500 naut. mi.

Control system for varying drag depends only on time and acceleration. This eliminates the need to have precise orbital information before a landing point can be predicted, and greatly simplifies the tracking requirements.

Avco said the control system can correct the effect of ellipticity, altitude error at the start of the controlled phase, errors in knowledge of the upper atmosphere, and density variations of either latitude or diurnal type.

Since the drag brake takes the place of a number of subsystems in retrorocket recovery scheme—including rockets, autopilot, orientation system, heat shield and parachute system for final landing—its reliability should be higher and its development should be quicker and less costly, Avco's researchers said.

Weight advantage of one-half in the comparison between a drag brake system and a retrorocket system would be reduced by 100 to 200 lb. if a good ablating material were used on the retrorocket system instead of a beryllium heat shield.

Japanese Fighter Hits New Snag; Missile Choice Problem Also Looms

Tokyo—The bitter controversy over selection of a fighter for Japan's Air Self Defense Force has reached a new peak of indecision amid a long series of delays resulting from conflict between the Japanese defense agency and members of Japan's Diet.

Latest development is that a new Japanese evaluation commission, which will include a team of crack pilots, will visit USAF's Edwards AFB and other installations within the next few months ostensibly to gather additional information on the three contender aircraft—the Grumman 98J-11 (version of F11F-1F), Lockheed F-104C and Northrop N-156F—before a final choice is made.

Japanese authorities are believed to have all the performance data they need, and the new evaluation commission is regarded as a move to justify the new postponement on a firm decision, which was scheduled to be made before the end of this month (AW June 15, p. 27).

Probable effect of the new delay is to push back the date when new fighter aircraft will become operational with Japan's Air Self Defense Force, thus shortening the period before obsolescence takes over. If Japan continues its internal conflict on fighter choice, observers point out, it may as well stick with the North American Aviation F-86s it now operates, fit them with advanced equipment, and wait until the Mach 3 F-108 becomes available.

Indications have been that the Japanese Defense Agency was sticking firmly to its choice of the Grumman 98J, which tentatively had been selected by the Joint Defense Council on April 12, 1958. Then this month indications were that, to resolve the bitter controversy between the Agency and members of the Diet, both the Grumman 98J and the Lockheed F-104C would be selected. Reports were that the compromise would involve about 200 Grumman 98Js and one wing of Lockheed F-104Cs, 75 planes, an increase from a previous projection of 50 F-104C aircraft. Another report had it that Lockheed would be given the entire order, thus excluding Grumman. Still another though less likely possibility advanced was that both would be scrapped and the Northrop N-156 chosen as a compromise.

Originally the United States was supposed to advance about $100 million in aid to Japan to implement its new fighter aircraft program, equivalent to about ⅓ the total cost. If two types of fighter aircraft were to be built, costs would increase and U.S. aid probably would also rise. One report is that originally the U.S. favored selection of Northrop's N-156, would have offered substantial assistance for the plane to be built entirely in Japan. Japan also would have had the right to supply Southeast Asia Treaty Organization (SEATO) nations with the aircraft.

Double Trouble

Feeling is that it would be a poor choice for both the Grumman 98J and the Lockheed F-104C to be selected for Japan's Air Self Defense Force. This would boost the outlay for Japan's fighter program, would mean double ground equipment, a duplicate training program for ground crews and fighter pilots and, with respect to any of the aircraft built in Japan, additional outlay for production tooling.

If both the 98J and the F-104C are selected, chances are that only about five of the 98Js, these for test purposes, would be built in the United States, with the balance manufactured in Japan. Probably all of the F-104s would be built in the United States at Burbank, Calif., but with some assembled in Japan from units shipped there. Probability is that Mitsubishi Heavy Industries would be the prime contractor, with Kawasaki as a subcontractor. Kawasaki now is building P2V-7 Neptunes, under Lockheed license at the rate of about one per month for a total quantity of 42.

Delay in ability to reach a decision on the selection of the fighters will have economic repercussions in Japan. Information is that the Japanese government, plus participation by Mitsubishi, already has invested a huge sum to establish the aircraft industry in Japan. Indications are that if the order for the new fighters is delayed, about 3 million man-hours per month will be forfeited in Mitsubishi activity alone. In the Kawasaki organization, the figure is estimated to be about 1,480,000 man-hours.

Japanese authorities also are aware of the need for missiles. Within the past two or three years, the Japanese government requested the United States to release several missiles including Nike Ajax, Nike Hercules, Sparrow, Bomarc, Sidewinder, Terrier, and Mighty Mouse, for research and study purposes.

Thus far, only Sidewinder has been sanctioned and the weapon will be delivered to Japan this fall. Initial procurement probably will total about 90 missiles. These are to be adapted to

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the Japanese Air Self Defense Force's F-86Fs at first.

Use of Sidewinder will be supplemented by an air-to-air rocket, similar to Mighty Mouse, designed and produced by Japanese industry. This missile probably will be used to arm the F-86D, of which 250 are expected to be released to Japan by USAF.

Sharp rivalry exists between the Japanese Ground Self Defense Force (Army) and the Japanese Air Self Defense Force for control of ground-to-air missiles. The Army now is preparing for the introduction of Nike Ajax, to be followed by Nike Hercules. The Air Force seriously is considering the use of the Boeing IM-99B Bomarc, with dimming interest in the Talos, which previously was under consideration.

Both the army and air force realize the need for Nikes and Bomarcs, but crux of the controversy is which branch of the Self Defense Force should have total control of them.

If present projections are realized, Japan may have 30 Nike squadrons and Hawk squadrons by Fiscal 1965. At that time, a number of Bomarc B squadrons also may be deployed in Japan. One stumbling block is Bomarc B's high price. Perhaps $50 million to $60 million would be required to complete a medium size Bomarc B site (28 shelters), which probably will accommodate about 56 missiles. Additional funding would be required for the Westinghouse GPA-335 control system.

In the ground-to-ground missile category, the Ground Self Defense Force is interested in Honest John and Little John, but evaluation of these missiles and their projected use will be phased in after the ground-to-air missiles are in the picture. One Japanese company now is developing an experimental ground-to-ground missile projected to have a range of approximately 300 mi.

AN/ASD-1 Contract

Washington—Air Force airborne electromagnetic reconnaissance system AN/ASD-1 will be developed by an industrial team of eight companies headed by Airborne Instruments Laboratory, division of Cutler-Hammer, under a $38.9 million contract recently awarded by Headquarters Air Materiel Command. The program is sponsored by Wright Air Development Center's Aerial Reconnaissance Laboratory.

Other members of the team are Aerojet-General, Filtron, Haller, Raymond & Brown, Raytheon, Sperry Gyroscope, Sylvania, and Temco. Director of the program is R. N. Close of Airborne Instruments Laboratory.

Congress to Approve Major Probe Of Aircraft, Missile Procurement

By Katherine Johnsen

Washington—Congress is expected in the near future to approve a major study of military procurement practices—particularly in the aircraft and missile fields—by the House and Senate Armed Services Committees acting jointly.

The investigation was authorized last week—in legislation extending renegotiation law—by the Senate Finance Committee, headed by Sen. Harry F. Byrd (D.-Va.). It would be followed by a thorough study of renegotiation by the Joint Committee on Internal Revenue—consisting of members of House Ways and Means Committee and Senate Finance Committee.

Staff studies on the first phase—procurement practices—would be carried on during the summer, with public hearings following, possibly this fall, but more likely in the next session of Congress convening in January.

A spokesman for Aerospace Industries Assn. welcomed the two-phase proposal of the Byrd committee as "even better" than the study of renegotiation procedures by a congressional committee which has been urged by the industry. "If the studies are fair and open—and I hope they will be considered studies and not investigations—and everyone is given a chance to put facts in the record, they are all we would ask for," the spokesman commented.

Industry Apprehension

There is great apprehension in the industry, though, as to the timing. Congressional criticism of military procurement—of over-pricing by aircraft and missile manufacturers (AW June 15, p. 27), of alleged industry efforts to weaken renegotiation law (AW June 8, p. 28), of the hiring of former military officers and defense officials by contractors, of alleged "munitions lobby" influence on weapons decisions (AW June 8, p. 25)—is at high-tide.

Meanwhile, there were these developments in military procurement:

• **Senate Finance Committee** voted to extend renegotiation law "as is" for two and a half years, to Jan. 1, 1962. The committee eliminated a series of amendments attached by House Ways and Means Committee (AW May 18, p. 29), and approved by the House, which Rep. Carl Vinson (D.-Ga.), chairman of House Armed Services Committee, charged were promoted by aircraft and missile manufacturers for their own benefit.

• **House Armed Services** Investigating Subcommittee aiming to open hearings on charges of influence by former military officers and civilian personnel on procurement by the second week of July, sent comprehensive questionnaires to the 100 largest defense contractors and their major subcontractors. The subcommittee's investigation will include all former Defense Department secretary-level personnel, as well as military officers above the rank of captain, former congressmen and congressional employes, and former employes at the White House and other executive agencies hired by defense contractors.

• **Rep. Alfred Santangelo** (D.-N. Y.), in a speech on the House floor, singled out for criticism USAF Lt. Gen. Clarence S. Irvine, who retired April 30, (AW June 15 p. 37). He declared: "(Bill) Irvine, who, until a month ago, was the Air Force deputy chief of staff for materiel and who advocated greater distribution of the defense contracts among smaller companies, was hired and engaged by Avco Corp. before his retirement . . . Avco Corp. has several major Air Force contracts, but is considered one of the smaller defense contractors. This announcement should have generated . . . an intense curiosity over the relationship of defense contracts and the pragmatic expediency by large corporations who hire retired military officers for new or more defense contracts . . ."

• **General Accounting Office** pushed its comprehensive investigation of management of USAF ballistic missile program with the goal of making a report to Congress within a month. The report will go to the Appropriations, Armed Services, and Government Operations Committees of the House and Senate.

• **Senate Armed Services Committee** postponed hearings on new military procurement legislation, scheduled to start June 22. A new tentative date of July 13 has been set, but it appears the hearings will be only perfunctory in view of the prospect for the joint military procurement study proposed by the Byrd committee.

• **House Armed Services** Investigating Subcommittee released a USAF instruction telling its negotiators not to be "preoccupied" with contractors' profits and cost estimates. The instruction said that "government procurement is primarily concerned with the reasonableness of a negotiated price and only secondarily with the eventual cost and profit." The instruction was revoked a few weeks ago, after General Accounting Office reported 14 cases of overpricing on USAF contracts totaling $30 million.

OPENING SESSION of the 52nd general conference of the Federation Aeronautique Internationale in the Hall of Columns of the House of Unions in Moscow shows E. N. Stepanov, president of the Chkalov Central Aero Club of the USSR, welcoming delegates and visitors from 30 countries. Among those on the dais are Jacqueline Cochran, FAI president; Marshal Simeon Zhavaronkov, deputy director of Aeroflot; Andrei Tupolev, winner of the FAI gold medal; Marshal Konstantin Vershinin, chief of the Red Air Force; Col. Gen. Belov, head of DOSAAF; and Alexander Yakovlev, Russian helicopter and all-weather fighter designer.

FAI Re-Elects Jacqueline Cochran

Moscow—Federation Aeronautique Internationale rejected an immediate extension of its jurisdiction to serve as the official record agency for outer space achievements at its 52nd general conference here but indicated it might consider such extension favorably in the future.

The outer space issue was presented by the United States delegation headed by Thomas Lanphier, president of the National Aeronautic Assn. as a result of an agreement reached by the FAI astronautical committee at Las Vegas, Nev., in April. The recommendations urged that if sufficient technical personnel was not available in FAI to handle the task that the International Astronautical Federation be requested to supply the necessary scientists.

The recommendation also urged that an appropriate program be presented to FAI for guiding space research "in the direction best suited to the needs of humanity." Also rejected was a Yugoslavian proposal that the general conference be held every two years instead of annually.

Jacqueline Cochran of the U. S. was re-elected president and Jacques Allez of France was re-elected first vice president. Barcelona, Spain was selected as the 1960 general conference site.

Among the recipients of major FAI awards presented by Miss Cochran at the Moscow meeting were:

• **Andrei Nikolaevich Tupolev,** constructor general of the USSR and member of its academy of sciences, the FAI gold medal for his work in aviation from 1901 to the present, during which he designed and constructed more than 120 different models of aircraft including the Tu-104 jet transport series and the Tu-114 turboprop transport. Tupolev's aircraft have set 35 international official records. He was a pilot and is a member of the USSR Chkalov Central Aero Club.

• **Capt. Walter W. Irwin, USAF,** the de la Vaulx medal for setting a new world absolute speed record of 1,404.19 mph. in a Lockheed F-104 Starfighter (AW May 26, 1958, p. 34).

• **Wolff Hirth,** German glider pilot and instructor, the Lilienthal medal for his work on behalf of gliding since 1920, including the setting of many glider record and his devotion to training glider pilots in many parts of the world despite the use of an artificial leg.

Paul Tissandier diplomas were awarded to the following in the U. S.:

• **Olive Ann Beech,** Wichita, Kan. president of the Beech Aircraft Corp. manufacturers of sport and executive aircraft.

• **Bertrand Rhine,** Los Angeles, vice president of the National Aeronautic Assn. and chief of its record timing organization for many years.

• **Paul A. Schweizer,** Elmira, N. Y.,

ANDREI TUPOLEV, Soviet designer who received the FAI gold medal, presents Jacqueline Cochran, FAI president with a special medal depicting the Tu-104 jet transport and a dove of peace enclosed in a circle of gold. On Tupolev's right is Marshal Zhavaronkov, deputy director of Aeroflot, and E. N. Stepanov, president of the Chkalov Central Flying Club of the USSR and conference host.

SOVIET DELEGATES to the FAI conference chat with U. S. visitors on the clubhouse balcony of the Chkalov Central Aero Club, at Tushino. From left to right are: Gregory Zhagaritchisky, deputy public relatioas director for Aeroflot; Alexander Yakovlev, Soviet helicopter and all-weather fighter designer; Sergei Ilyushin, jet bomber and transport designer, and Ralph Alex of Sikorsky Aircraft and president of the American Helicopter Society.

JACQUELINE COCHRAN, Federation Aeronautique Internationale president greets three FAI gold medal winners. From left to right, James H. Doolittle, president of Space Technology Laboratories; Andrei Tupolev and Lt. Col. Charles Yeager, first pilot to fly faster than the speed of sound.

MASS PARACHUTE DROP from a formation of nine Il-14 military transports is made by members of the Chkalov Central Flying Club as the finale to their air show staged for delegates to the FAI 52nd general conference in Moscow. Air show was held at the club's headquarters on Tushino airdrome on the outskirts of Moscow.

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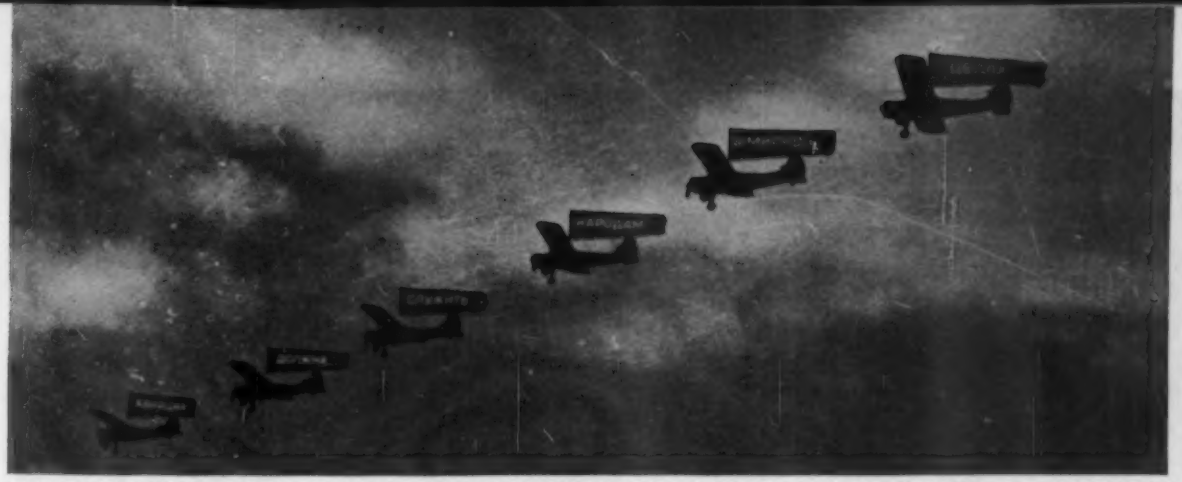


OPENING PARADE of the Chkalov Central Aero Club air show at Tushino was a fly-by of Yak 12 sportplanes flying banners that spelled out a slogan calling for development of aviation for peaceful purposes. Show also featured acrobatics in high performance gliders, formation acrobatics by women pilots, balloon busting competitions and a fly-by of the latest Soviet jet transports and helicopters.

president of the Soaring Society of America.

• **Steve Wittman,** Oshkosh, Wis., famous racing pilot, for his contribution to closed course air racing.

Three new groups were admitted to membership in FAI. They are the Korean Institute of Civil Aviation (South Korea); the Central Aero Club of the Democratic Republic of North Korea and the Federation Royal Marocaine des Sports Aeronautiques.

A proposal by Miss Cochran to establish a special FAI award for any aircraft that simultaneously held three world records was rejected by the delegates primarily on the USSR's objection that only a military plane could win such an award.

Miss Cochran also proposed establishment of an FAI foundation to finance increased youth activity in aviation. The USSR delegation headed by E. N. Stepanov supported this proposal on the grounds that it could expand aviation in the underdeveloped areas of the world and also expand the scope of FAI activities.

Chkalov Central Aero Club of the USSR, headed by Stepanov, was host to the conference.

Among the prominent Soviet officials who participated in the meeting were Marshal Simeon Zhavaronkov, deputy chief of Aeroflot; Col. Gen. Belov, chief of DOSAAF, the voluntary organization for the support of the military services which sponsors much glider, parachute, helicopter and light sport flying in the USSR; Marshal Konstantin Vershinin, chief of the Red Air Force, and Lt. Gen. Sergei Shatilov of the Central Aero Club.

Two Soviet deputy premiers, Anastas Mikoyan and Frol Kosslov also addressed the FAI delegates. Mr. Mikoyan deplored the fact that it was not possible for foreign airmen to fly freely over all portions of the USSR.

"This is purely for defensive reasons, not offensive policies," he told the delegates at a lavish dinner Miss Cochran sponsored for the conference at the Sovietskaya hotel. "This is because our military people think your people in the Pentagon have some funny ideas. Maybe what we need to do in both countries is to ignore our military and work toward the day when it will be possible for you to fly your sport planes freely over any country in the world."

Mr. Mikoyan also suggested that if the foreign ministers conference in Geneva failed to produce a solution to the Berlin problem it might be wise to call in women from all countries concerned and ask them to solve the problem.

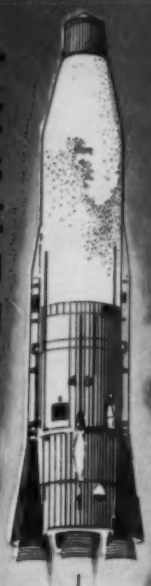
Mikoyan's speech was heavily censored by official Soviet censorship when filed to the United States by resident correspondents of U. S. newspaper and wire services.

Chkalov Central Aero Club members staged an air show at their Tushino airdrome clubhouse for the FAI delegates featuring a fly-by of the Tu-104B, Il-18 and An-10A jet transports; the Mi-4, and jet powered Mi-6 helicopters; the Yak-24 twin rotor helicopter and the Kamov Ka-15 coaxial rotor helicopter. The An-14 STOL transport gave a startling demonstration of its performance—getting airborne with less than 50 ft. roll from a standing start and climbing out at a steep angle. The An-14, which has just finished its development test trials and is scheduled to go into service shortly with Aeroflot as a feederliner and bush plane, also completed its landing roll in less than than 100 ft. after touchdown on an extremely steep approach angle.

Other features of the air show included spectacular aerobatics in a new metal high speed glider designed by Oleg K. Antonov which included outside loops and a 200 mph. low altitude pass across the Tushino grass airdrome; formation aerobatics by another glider trio and balloon busting contests between teams of Yak-18 trainers with a referee observing the competition from a Mi-1 helicopter.

MEMBERS OF THE FAI sporting committee in working session include (left to right) Richard Horner, associate administrator of NASA; Bertrand Rhine, Los Angeles attorney; Thomas G. Lanphier, president of the National Aeronautics Assn. and chief of the U. S. delegation to the FAI conference, and Georges Hanet of Belgium.

MOST OF THE ANSWERS MUST BE KNOWN IN ADVANCE



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RUSSIAN Mi-6 twin jet helicopter designed by Mihail Mil is shown in flight with a new movable semi-span wing in preparation for its planned assault on the world absolute speed record for helicopters. The movable wing, located on both sides of the fuselage, is used to unload the rotor blades under certain flight conditions. Mi-6 is powered by two 5,500 lb. thrust Soloviev gas turbines and has a small gas turbine mounted above and between the main engines as an auxiliary power source. Also note streamlining of upper fuselage below rotor head.

Mi-6 Helicopter to Attempt Speed Record

By Robert Hotz

Moscow—Russia's twin jet powered Mi-6 helicopter will attempt to shatter the world speed record for helicopters within the next 60 days and set a new mark of more than 200 mph. Plans for the Soviet helicopter record attempt were disclosed to delegates at the Federation Acronautique Internationale conference here by Mihail Mil designer of the Mi-6 and other single rotor helicopters.

The present world speed record is 162.8 mph. set by a Sikorsky S-56 helicopter. The British Fairey Rotodyne set a 191 mph. record in level flight but used two Napier Eland turboprop engines for forward speed after unloading the rotor.

Aerodynamic Breakthrough

Mil indicated a major breakthrough in helicopter aerodynamics had enabled the Mi-6 to reach the long sought 200 mph. level flight goal of helicopter designers on both sides of the Atlantic. The Mi-6 had earlier encountered development problems that had restricted its forward speed to about 90-100 mph. but the "breakthrough" plus other modifications have produced a better than 200 mph. forward speed capability in its present configuration, according to Mil.

Among the modifications noted during the Mi-6 flypast at Tushino, and in newly released pictures, are a movable semi-span wing located high on the fuselage just behind the rotor head, removal of the wheel pants and fairings on the main gear and a new streamlined configuration of the top fuselage below the rotor head.

The Mi-6 has a maximum gross weight of 70,000 lb. and an empty weight of 41,000 lb. Although designed primarily for geologic survey work in cataloging Siberia's mineral resources, it can carry 80 passengers in a transport configuration. It is powered by two Soloviev 5,500 lb. thrust gas turbine engines mounted on top of the fuselage with tail pipes exhausting to each side.

Earlier this summer the Mi-6 claimed two new load carrying records operating from the helicopter development test field near Khimki, a Moscow suburb (AW May 25, p. 84). On one flight the Mi-6 carried a payload of 11,025 lb. to an altitude of about 18,045 ft. topping the previous mark of 12,220 ft. by a similarly loaded Sikorsky S-56. Two hours after this flight the Mi-6 lifted 22,050 lb. to 16,045 ft. surpassing its own previous record for this load.

Geologic Survey

Designer Mihail Mil built the Mi-6 primarily to meet a requirement for the geologic survey of Siberia and 30 machines have been ordered to date for this work. Five Mi-6 helicopters have been built for the development test program; one was destroyed in an accident. The large cubic footage of the Mi-6 cabin is designed to accommodate trucks, heavy drilling rigs and caterpillar vehicles plus the personnel required for the geologic survey teams. It has a rear clamshell loading door with integral ramp. For the Siberian work it is required to carry a 12 ton load to 12,000 ft. to operate in the Ural mountain area.

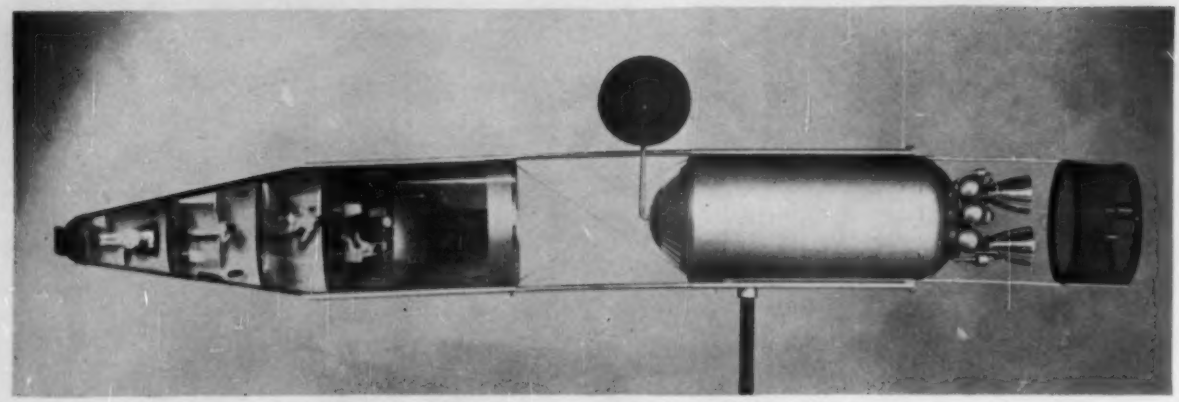
Helicopter vs. VTOL

Mil has been discussing a transport configuration of the Mi-6 with both Aeroflot, the Soviet airline and Sabena, the Belgian national airline that now operates the largest commercial helicopter transport network in the world.

From conversations with other Soviet helicopter designers, including Alexander Yakovlev, who works in the twin rotor designs, and Nikolai Kamov, who specializes in coaxial rotors, FAI delegates concluded that the Soviets are placing heavy emphasis on helicopter development for both military and civil purposes and have virtually abandoned VTOL type research after conducting experimental tests with a turboject VTOL similar to the French Snecma, British Rolls-Royce and U. S. Ryan developments and another turboprop powered configuration using the tilt-wing principle.

Among other Soviet helicopter developments are:

• **Yakovlev is working** on a new twin rotor configuration even larger than his Yak-24 model which is still in production for both military and civil uses. The military version of the Yak-24 car-



Convair Proposes Five-Ton Satellite

Configuration of a five-ton satellite vehicle proposed by Convair-Astronautics to orbit at 300-mi. altitude (AW June 15, p. 33) is shown in model form. The four-man vehicle could be used as a space laboratory or as a training station for space flight crews. Station could be boosted into orbit by Atlas-Centaur combination. Rails on sides of vehicle would permit lengthening of vehicle to make a longer turning axis. This would increase artificial gravity effect achieved when vehicle is rotated on its longitudinal axis, thereby combatting weightlessness. Extension would also give crew added protection from atomic auxiliary power supply. Center section is Centaur upper stage.

ries 41 troops or an assortment of small artillery and vehicles while a 30-passenger version has been built for Aeroflot.

• **Kamov Ka-15 is in large scale** production primarily as an agricultural pest control machine. It is equipped to use both insecticide dust and liquid sprays and can carry a 600 to 800 lb. spray load. Heavy downwash from the coaxial rotors provides unusually good dusting performance. Ka-15 is also in service with Aeroflot on mail runs.

• **More than 6,000 helicopter** pilots have been trained in the Soviet Union since World War II, most of them on the Mi-2 two place training helicopter which is seen in quantity on almost every civil airport in the USSR.

• **Central Aero Club** has conducted large scale helicopter sport competitions in spot landings, flights over obstacles and on a precisely operated triangular course emphasizing pilot skill. Club is now taking initiative in establishing international standards for such competition in which helicopters competing are handicapped according to performance characteristics to place competitive emphasis on pilot skill.

Top Contractors

Washington—Boeing Airplane Co. again led the list of 100 U. S. companies and their 144 subsidiaries that received the largest volume of military prime contracts for the calendar year 1958. Next in order were General Dynamics Corp., General Electric Co., Lockheed Aircraft Corp. and North American Aviation, Inc. North American moved up from seventh place on the Fiscal 1958 list (AW Feb. 23, p. 117) to replace United Aircraft Corp., which dropped to 14th place. Chance Vought Aircraft, Inc., dropped from 12th place in Fiscal 1958 to 65th in the new list. Grumman Aircraft Engineering Corp. dropped from 21st to 47th place. Thiokol Chemical Corp. moved up from 51st to 39th and Chrysler Corp. from 20th to 12th. Boeing was awarded $1,894,500,000 or 8% of the $23,817,100,000 total awarded to the 100 companies. These companies received $17,633,400,000 or 74% of the total defense contracts awarded in Calendar 1958. They subcontracted 49.5% of this.

News Digest

Agreement may be reached shortly on establishing the third site of USAF's Ballistic Missile Early Warning System (BMEWS) near Prestwick, Scotland. Target detection and tracking data from the Prestwick site will go to British defense personnel as well as North American Air Defense Command.

Entire X-15 glide flight was made with use by North American pilot Scott Crossfield of the sidearm control lever rather than the conventional center control stick. Sidearm control is designed principally for high-g flight forces and requires only wrist movement to maneuver the aircraft.

Radio Corp. of America has been selected by Air Force to develop its new 466L electronic intelligence data processing system (AW May 11, p. 23).

Winner of 1959 Harmon trophy is Maj. Andre Edouard Turcat, of France, chief test pilot of Nord Aviation and former director of flight test school at Bretigny. He was named winner for being world's first test pilot to exceed Mach 2 in a ramjet-powered experimental aircraft, the Nord Griffon 2.

Western Allies are easing their restrictions on West German missile production to allow the country to participate in European community production of Army-Raytheon low altitude anti-aircraft missile. Restrictions, which are being waived for Hawk only, limit West Germans to production of missiles with a length of no more than 6½ ft. and a diameter of about 12 in.

Grumman Aircraft Engineering Corp. will build 10 SA-16B Albatross amphibians for Royal Canadian Air Force rescue and utility use. Though Canada dropped its usual preference for building the airplane in Canada under license because of the small number involved, Grumman agreed to subcontract part of the airframe to Bristol Aero Industries and also to let a $1 million contract for components for U. S. Navy S2F aircraft to a Canadian company, Enamel and Heating Products, Ltd. Further, Wright R1820-82 engines, built by Canadian Pratt & Whitney for Canadian-built S2Fs, will be used in the SA-16s instead of R1820-76 engines originally specified.

Feasibility studies for large nuclear powered helicopters have been completed for the Air Force by Bell Helicopter Corp. Single and multi-rotor vehicles up to 500,000 lb. gross weight and 300 ft. in length with more than 200 mph. cruise speed were considered in the study. Nuclear engine and shielding weight are considered to be lower for such helicopters than for high performance aircraft because of a lower power required.

Continental Foresees Trunkline Mergers

Airline plans its jet equipment and finance program to prevent loss of its identity as seat-miles increase.

By L. L. Doty

Los Angeles—Continental Air Lines has mapped its jet transport program on the strong supposition that trunkline mergers are inevitable within the next one or two years.

The airline is basing its prediction on the theory that the rapid expansion of available seat miles resulting from a widescale introduction of high-speed, high-capacity jet equipment will drive a number of small carriers into partnership with their stronger colleagues. Just how many companies will be involved in the forecasted dovetailing of routes Continental is not prepared to say.

However, the airline is convinced that the companies which will retain their identities through the merger period will be those companies which have avoided certain costly mistakes in launching their re-equipment programs.

Continental Program

To ensure its future—to make certain that it will not be swallowed up in an enforced merger—Continental has patterned its jet program this way:

• **The airline has planned** its financing covering its current re-equipment program so as to be out of debt by 1963. Earned income thus will not become bogged down in fixed charges to prevent reinvestment in the even newer equipment that Continental feels the industry will be forced to purchase within the next five years.

• **Over-investment** in any single type of equipment has been avoided. First of the eight "regional" trunklines to inaugurate turbojet equipment, the airline will be offering 80% of its available seat miles with turbine aircraft by the end of the year. Its present fleet—two Boeing 707s with an additional two to be delivered in July and August, 15 Vickers Viscount 810s, five Douglas DC-7Bs and one DC-6B—has been carefully keyed to the route structure of both medium-haul and long-haul runs. Continental was the first major airline to dispose of its surplus piston-engine fleet.

• **Competition against major** trunklines on its Chicago-Kansas City-Denver-Los Angeles route was developed to avoid the use of equipment inferior to that of its competitors. The carrier held off the inauguration of the Chicago-Los Angeles service until it was able to match its competitors with DC-7s. Thus the carrier attained immediate prestige in the market. That this position was strengthened last year with the introduction of Viscounts is demonstrated by the fact that 50% of the first-class business in the market now belongs to Continental.

• **Route pattern of Continental** has been strengthened substantially. Its Chicago-Los Angeles route makes it a natural partner for carriers with high-density routes in the east. The airline is conducting a strenuous campaign to transfer its small intermediate cities with low traffic potentials to local service carriers. It is seeking nonstop rights from Chicago, Kansas City, Denver, Los Angeles and San Francisco. It is also looking for routes from its Texas cities to the West Coast.

Robert F. Six, president of Continental, is convinced that these factors will carry his company through the merger period without threatening any loss of its identity, management makeup or key personnel structure. In discussing the possibility of smaller airlines being forced into mergers because "this business is so expensive," Six says:

"That may be right for any airline which doesn't have the financing, the equipment, the passenger service, and the people . . . but we have them all."

On his equipment program he said that "we are looking at short-range jets for use over the Southwest-California runs and long-range intercontinental Boeing 707-320s or forward-fan 120Bs for the Honolulu run." Looking even farther in the future, Six and his staff have made detailed studies of supersonic jets on grounds that the high-speed aircraft are less than five years away—a sharp contrast to the 10-15 years forecast being made generally throughout the industry.

Continental's current re-equipment program—involving a total cost of $64 million for the Boeings, Viscounts and DC-7Bs—was launched in 1955 when the carrier's net worth amounted to $5.5 million. To back this investment, the airline has employed a number of financing devices—none of which involved equity financing.

Equity Financing

Issuance of new stock has not been included in the over-all program because of doubts that large bulks of common shares could be sold successfully at the time the refinancing was planned. However, the airline has indirectly achieved a large-scale equity financing undertaking through the issuance of two series of convertible debentures.

As of June 1, $7.3 million of a $12.5 million, 5¾% convertible subordinated debenture issue had been converted to common stock at $6.50 per share. A total of $3.3 million out of $4,125,000, 4¾% convertible subordinated debentures had been converted to common stock at $7.96 per share at the same time. Company's stock, which is listed on the American Stock Exchange, has varied between a high of 10⅛ to a low of 7⅛ during the year.

Effect of the conversions is illustrated by these figures: at the end of 1958, Continental had 765,000 shares of common outstanding with a total of 3,300 stockholders on record. As of June 1, there were 1,640,000 shares outstanding and recorded stockholders totaled 6,700. Privately, some company officials are predicting that the number of stockholders will reach 15,-

Supersonic Transports

Los Angeles—Interest in supersonic jet transports by Continental Air Lines President Robert F. Six and his top-level staff has convinced these officials that development of such an aircraft is not as far off in the future as is generally believed. Their guess is that a prototype will be completed within five years and that the supersonic plane will play a significant and practical role in commercial air transportation.

High cost of the aircraft, they say, could be offset through pooling arrangements among the airlines, through a joint-purchase plan or through lease by a purchaser to operators. Because of its high speed, the supersonic airplane, under a pooling agreement, could serve long-haul routes of several airlines during its daily period of utilization.

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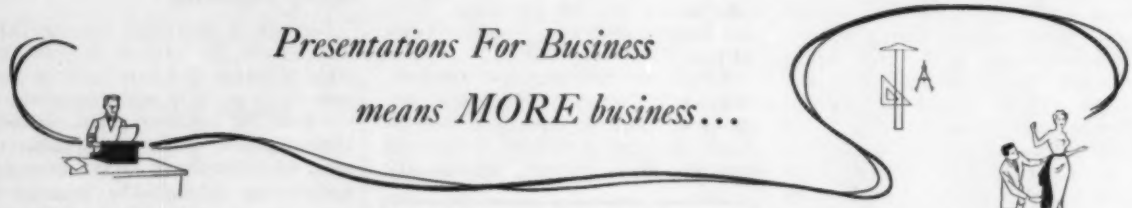

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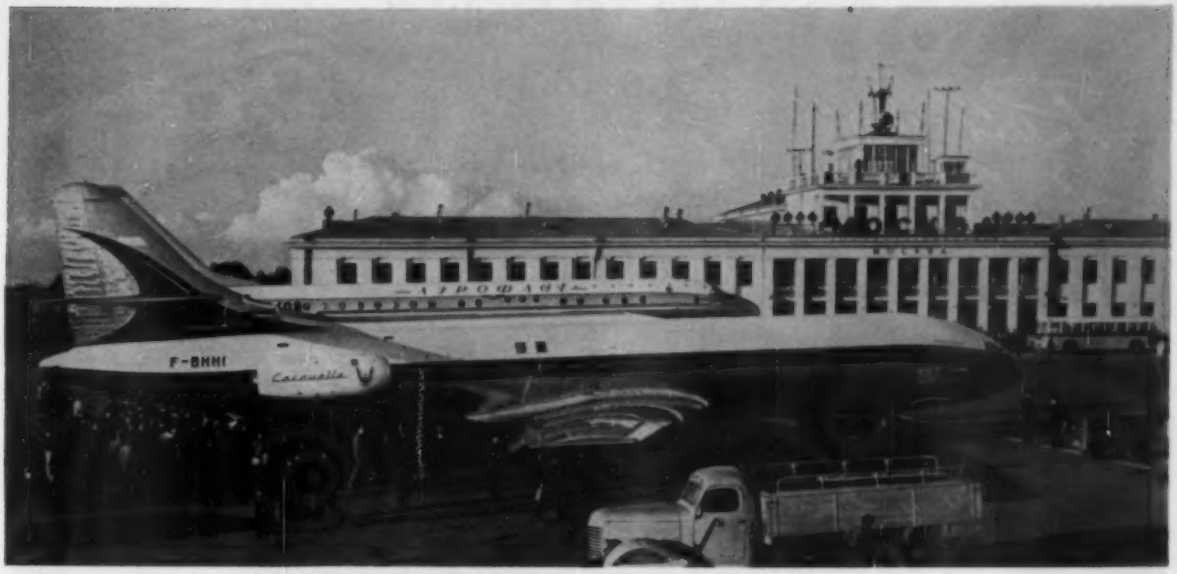

Caravelle Prototype Lands at Moscow

Preview of Air France Caravelle jet service into Moscow was provided by the arrival of one of the prototype Caravelles at Moscow's Vnukovo airport bringing the French delegation to the 52nd general conference of the Federation Aeronautique Internationale. The Caravelle shown at Vnukovo with a Tu-104B of Aeroflot in the background is expected to begin Paris-Moscow service in November with a stop at Warsaw, replacing the Super Constellations that are now competing with Tu-104 twin jets of Aeroflot on this route.

000 during the next few years.

Interest savings resulting from the conversion of the debentures to common stock are, of course, looked upon by officials as an important factor in the current refinancing program.

Continental also holds a $26.5 million bank credit agreement out of which about $15.9 million has been drawn down in loans. The company raised $750,000 through the sale of its maintenance base located on leased grounds at the International airport here. Under a lease-back agreement, the carrier has use of the facilities at a rental of $12,450 per month for a term of 84 months. Overhaul of the company's Pratt & Whitney JT3 engines is being handled by Pacific Airmotive Corp. here.

During the year, deliveries of 10 of the 14 aircraft sold will realize a net capital gain of about $1.1 million. To maintain service on its smaller routes, the airline has leased 10 DC-3s until the end of 1960 and has rented three Convair 240s for use this summer.

Other miscellaneous financing aggregating $298,802 has been consumated. Total depreciation—which amounted to $3.3 million last year—and retained earnings will cover the balance of the re-equipment program.

Indebtedness has caused a substantial increase in interest expense. Last year, interest expense, exclusive of $216,691 of interest capitalized, climbed to $736,587 or 101% over 1957.

Transition costs and expenses stemming from the expansion of service brought 1958's operating expense to $4.8 million or 21% over the prior year. The Boeing turbojet program has been budgeted at $23.8 million.

The 22% increase in operating revenues in 1958 over 1957 to bring the total to a company all-time high of $28.5 million is expected to be outstripped this year. During the first two weeks of operation, the Boeing 707s have been operating at peak capacity and have had no operating difficulties.

The new route providing nonstop services to the area between Dallas and Albuquerque/El Paso, which was opened in April, is expected to gross $4 million in additional revenues during the nine months of its operation this year. With traffic up generally and with a boost in fare levels, Continental is now anticipating a profitable year that will place it in an enviable position when merger talks begin.

Gross revenues are expected to top $40 million in 1959 and total assets should pass the $75 million mark by September, compared with the total assets of $57.6 million reported Dec. 31. Net worth will probably reach $12 million by the end of the year.

That the airline is not overly optimistic in projecting these results is indicated by the fact that during the first week of Boeing 707 operations, 6,000 advance reservations had been booked. According to company officials, this was due to a gradual build-up of both internal and external promotions of the jet service long before schedules were actually introduced.

The entire advertising program was well underway at the time Pan American and American began their turbojet schedules so that Continental was able to identify itself to the traveling public with turbojet operations six months in advance of its regularly scheduled service. Such advertising programs, which featured the interior of the aircraft rather than the exterior, were strongly buttressed by advertisements supporting the Viscount turboprop services.

Advertising budget in 1959 will reach $2.3 million—about 5% of the forecasted gross for the year. Although the ambitious program is characterized by a series of four-color newspaper ads, the carrier is placing emphasis on its direct mail program as the media most likely to generate the traffic it needs to fill jet seats.

Internally, the company conducted a series of educational programs to keep personnel informed on the potentials of the new fleet. Approximately $750,000 is being spent on training of flight and ground crews. Full training programs were started early enough to permit Continental, which has never been grounded by a labor strike, to become the first U. S. airline to begin jet schedules with regular line pilots rather than supervisors.

Number of revenue passengers carried this year is expected to pass one million for the first time. Last year, the company carried 853,931 passengers a total of 422.4 billion revenue passenger miles. Revenue passenger miles in 1959 may exceed 500 billion, according to sale officials.

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Quesada Clashes With ALPA Chief On Pilot Duties, Enforcement

Washington – Federal Aviation Agency Administrator E. R. Quesada last week denounced Air Line Pilots Assn. charges that FAA inspectors are employing "childish Gestapo" tactics in requiring pilots to remain in the cockpit at all times during a flight and warned ALPA that the agency "will not be threatened into retreat" from its responsibility to prevent midair collisions.

While deploring "what appears to be calculated abuse" of the FAA and its inspectors, Quesada replied that he is far more concerned over the possible adverse effect such publicity might have on public confidence.

Quesada made these comments in a letter to Clarence N. Sayen, ALPA president, who had accused FAA inspectors of timing lengths of visits by pilots to passenger cabins and filing violation reports against them (AW May 25, p. 38).

He told Sayen that it was not only essential that the public understand that most pilots are deserving of the trust placed in them but that "most pilots do not share your views."

In particular, Quesada said he was "astonished by the note of intimidation" he read into the ALPA president's inference that "vigorous enforcement" of safety regulations on flight deck vigilance would be met by a "program of non-cooperation" among airline pilots. The administrator said that he hoped the inference was "an accident of language rather than a statement of intent." As fare paying passengers, the public has the right to expect "full time service" from the pilots with whom they fly, he added.

Sole Objector

Quesada also pointed out that Sayen was the only objector to an FAA letter of Mar. 3 to airline presidents, the military, and organizations representing both private and corporate fliers, appealing for increased pilot vigilance and observation of the "see and be seen principle." The letter highlighted the need for stricter observance of Civil Air Regulations requiring all flight crew members to remain at their stations while taking off, landing or en route, except where the absence of one may be necessary in connection with operation of the aircraft.

The pilots of some 92,000 military and private planes have the right to demand that "they be seen," Quesada emphasized, not only by each other, but by the pilots of the 1,900 commercial aircraft. Precautions to avoid air collisions must be "equally and uniformly binding on all pilots," he added.

Sayen's assertion that the FAA letter of Mar. 3 "has had the effect of a new regulation" was also discounted by Quesada who stated that "not so much as a comma had been changed" in the Civil Air Regulation, passed April 1, 1954, governing flight crew member absence from the cockpit. In addition, the administrator reminded Sayen that Part 61.7801 of the Civil Air Regulations also spells out the requirements for flight crew vigilance and was passed in 1936.

As examples of cases justifying strict enforcement of FAA cockpit regulations, Quesada cited the recent uncontrolled dive of a Boeing 707-120 jet transport over the North Atlantic (AW Feb. 9, p. 39) and an earlier near miss between a Douglas DC-7 and an Air Force tanker engaged in refueling two fighter planes.

Although the military tanker pilot saw the airliner at a distance of one mile away, said Quesada, the DC-7 pilot gave no evidence of ever having seen the Air Force plane. Investigation disclosed that the airline pilot was in the passenger cabin "for reasons we contend were neither incident, nor necessary, to the performance of his duties," he told Sayen.

In the 707 incident the pilot also was in the passenger cabin, "for reasons not necessary to his normal duties," said the administrator, who added that "had he not demonstrated extraordinary courage and skill in getting back to the flight deck in time to retrieve his error, aviation could have experienced its greatest single air disaster."

'Rhetorical Circus'

Reviewing Sayen's accusations that FAA inspectors had engaged in "petty and childish harassment" in reporting flight crew violators, Quesada said the ALPA president had employed "invective, in the absence of evidence" and attempted to make a "rhetorical circus" of the issue by charging them with conducting a "childish Gestapo" program.

Noting that Sayen had failed to offer any evidence to discredit the discretion or judgment of the FAA inspectors, and that most pilots "appear tolerant" of the agency's efforts and cooperate, Quesada warned that he will "vigorously defend this agency's inspectors on any and all occasions when they are subjected to unwarranted attack in the performance of their lawful duties."

CAB Pushes ATA Files Demand

By Robert H. Cook

Washington—Civil Aeronautics Board, currently investigating the operations of the Air Transport Assn., last week pressed its demand for greater access to ATA files by ordering the organization to comply with new requirements.

Civil Aeronautics Board ordered an amendment to include the following conditions:

- **Complete minutes** shall be maintained on meetings of the board of directors of ATA, the general membership of the organization and the Air Traffic Conference, plus any other conference which may be formed in the future. Minutes are to be filed with the CAB within 30 days after meetings have been held.
- **Copies of existing resolutions** adopted by ATA and its divisions must be filed with CAB by July 10 and any further resolutions adopted in the future will also be filed within 30 days after adoption.
- **Copies of written opinions** and reports submitted by the director of the ATC enforcement office, along with decisions of arbitrators involved, since Jan. 1, 1956, must be filed with the Board. In the future such material would also be filed with CAB within 30 days after submission. In answer to objections of many carriers that such information might be used as the basis for proceedings instituted by the Board's Office of Compliance, thus destroying essential cooperation between the airlines and the Air Traffic Conference enforcement office, CAB stipulated that carriers involved need not be identified by name but would only be classified in the categories of territorial, local service, cargo, domestic trunk, international trunk and Canadian airlines.
- **Copies of all other** material submitted by the ATC enforcement office to member carriers since Jan. 1, 1956, and in the future, shall be filed with CAB by July 10.
- **List of all files destroyed** by both ATA and its member carriers since Jan. 1, 1956, shall be submitted by the organization and individual carrier members for filing with the CAB by July 10.
- **If either party is unable** to comply with the order on files destroyed, it must file with the Board a statement disclosing the plan under which the files were destroyed and naming the person who formulated the plan.

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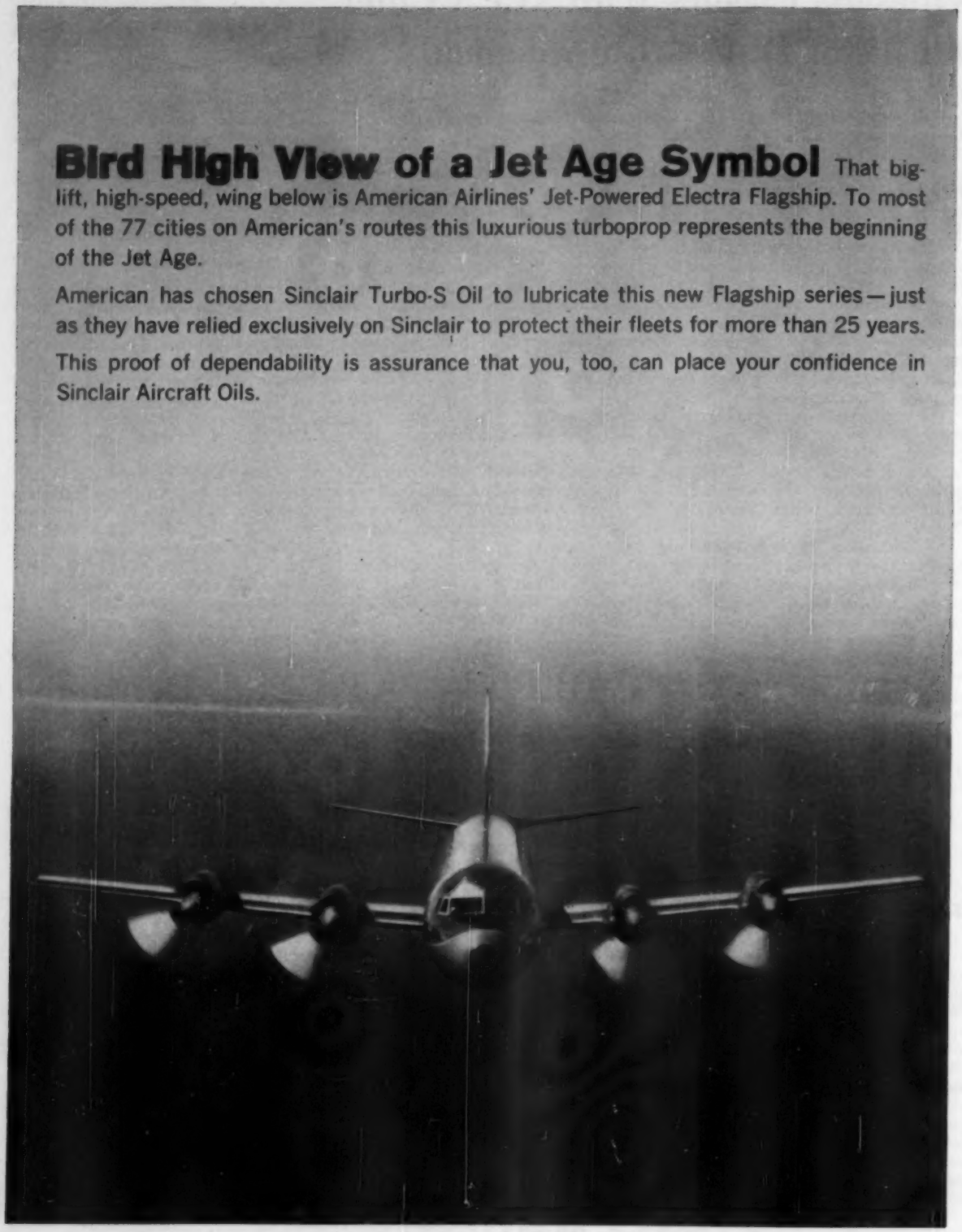

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SHORTLINES

▶ **Capital Airlines** is offering daily stock market information on its four late afternoon "VIP" luxury flights from New York to Chicago, Detroit and Birmingham through the cooperation of Bache & Co., member firm of the New York Stock Exchange. The newsletter contains a market summary for the day and the closing prices of a few key stocks.

▶ **Channel Air Bridge,** an independent British airline, plans to purchase 10 Douglas DC-4 aircraft and convert them to accommodate automobiles. The airline, subject to British government approval, wants to operate the airliners on its routes to France and Germany, now served by nine Bristol Super Freighters.

▶ **Federal Aviation Agency** Administrator Elwood R. Quesada is presiding as chairman of the United States delegation at the 12th session of the International Civil Aviation Organization Assembly in San Diego, Calif., which began June 16 and will run for a month.

▶ **Flying Tiger Line** air freight revenues in May rose 30.4% over the same month in 1958 to $1,254,296. Flying Tiger freight traffic revenue for the first five months of 1959 totaled $5,902,056, a gain of 34.9%.

▶ **KLM Royal Dutch Airlines** will install an International Business Machines Corp. 705 model electronic computer to mechanize its accounting system in company offices at The Hague, Holland. The machine, which was manufactured in France, will be the first of its kind to be used by a European airline.

▶ **North Central Airlines** carried 85,365 revenue passengers during May, 37% over May, 1958 and a new monthly record for the local service carrier.

▶ **United Air Lines** operated 438,887,000 revenue passenger miles during May, up 4% from the same month a year ago. Other May figures include: revenue airplane miles, 11,336,000, about equal to May, 1958; freight ton-miles, 6,588,000, up 25%; first class and air mail, 3,006,000 ton-miles, up 13%; express, 1,056,000 ton-miles, up 31%.

▶ **Quebecair of Canada** has placed an order for a third Fairchild F-27 turboprop airliner with scheduled delivery set for the end of July. The airline already operates two F-27s.

AIRLINE OBSERVER

▶ **Trunkline traffic during May showed the sharpest gain recorded in any month since August, 1957. Revenue passenger miles reached 2.28 billion, slightly short of the all-time high of 2.38 billion reported last August but 16.4% higher than the total moved in May last year. Available seat miles rose to 3.80 billion—an 8.7% increase over May 1958—to give the trunkline industry a load factor of 60.09%. May is the eighth consecutive month that load factors have moved up over the corresponding month in the previous year. Before this upward trend began, the industry average load factor declined every month but one over a two-year period. Traffic activity so far this month indicates that June will show the same healthy growth pattern that began early in the year.**

▶ Air India International is showing strong interest in a medium-range turbine transport to supplement its fleet of three Boeing 707-320 Intercontinental turbojet transports now on order. The carriers interest is now centered on the Boeing 720 turbojet and the Lockheed Electra turboprop. Both manufacturers have backed their offers with attractive deferred payment plans covering the purchase price of the aircraft.

▶ **Capital Airlines will purchase a fleet of Lockheed Electras if it can complete a financing program that would refinance its current notes on the Vickers Viscounts as well as cover the Electras. Plans to add the Electras to its fleet will not change the airline's decision to buy Convair 880 turbojet transports although the initial order of nine may be reduced slightly.**

▶ American Airlines has changed its jet operating procedures to allow for the variations of wind along a runway when wind is calm or near calm. In computing allowable takeoff weights under a new rule, three knots are subtracted from expected headwind component when the component is three knots or less. Thus, if headwind component was plus three, it would be figured as zero; if it was plus two it would be figured as minus one.

▶ **East German aviation industry is making a strong bid to sell the Baade 152 turbojet transport to Iraqi Airways. Iraqi Airways, which is in the market for small jets to serve projected routes to the Far East, North Africa and Moscow, was told that delivery of three aircraft could be completed by 1961. Cost of each airplane is about $2 million and payments could be handled in four annual installments.**

▶ Continental Airlines has equipped all its ground service equipment with antenna-like rods set at an angle of about 45 deg. Ignitions of the mobile units are cut and brakes are automatically activated when the tip of the rod comes in contact with the aircraft being serviced on the ramp. Carrier expects the device will substantially reduce ground damage to aircraft.

▶ **Air Transport Assn. board of directors has approved a new program to expand credit uses of universal air travel plan (AW Dec. 15, p. 38). The program tentatively calls for issuance of the new cards by Aug. 1.**

▶ Midair collision reports are revealing an "alarming unfamiliarity by pilots of the semicircular rules," according to the Federal Aviation Agency. As a result, the agency is urging all pilots to study regulations covering VFR flights above 3,000 ft. Specifically, semicircular rules call for operation of VFR flights at odd thousands plus 500 ft. when on a magnetic course of zero degrees to 179 deg. and at even thousands plus 500 ft. when on courses of 180 deg. to 359 deg. below 29,000 ft. and above 3,000 ft.

▶ **United Air Lines will convert six Douglas DC-7s to cargo aircraft. Cost of the conversion, which will be done by Douglas Aircraft Co., will be $3 million. The six DC-7s will supplement the seven DC-6A cargoliners now in operation throughout the United system.**

▶ National Airlines has signed an agreement with Quality Courts United, a 500-member motel association, to provide complete travel packages which include air transportation, special rental car arrangements and motel accommodations without the need of advance reservations.

Hot Weather Adds to Jet Noise Problem

New York—The simmering jet noise problem at New York International Airport will become more critical this summer as the "open window" season arrives at neighboring communities, and at the same time jet frequencies are stepped up by the airlines. Adding to the problem is the hot-weather loss of performance of the jets, which cuts allowable takeoff weights on length-restricted runways.

The Port of New York Authority's Executive Director Austin Tobin, subject of a major controversy last year when he blasted the noise characteristics of the Boeing 707-120 (AW Sept. 8, p. 39), recently protested publicly that jet noise complaints are heavy and that the communities won't tolerate additional noise. Five airlines now operate jets at Idlewild under Port Authority anti-noise regulations including preferential jet runways.

'Poor Record' Airlines

Two of the Boeing 707-120 operators, American Airlines and Trans World Airlines, have achieved a "poor record" of conformance with the noise procedures, according to the Port Authority.

The agency's jet takeoff monitoring from the beginning of first operations last October through May, 1959, produced these statistics:

Airline	Number of Takeoffs	Violations	% Violations
American	759	305	40
Aerolineas Argentinas	7	0	0
BOAC	210	7	3.3
National	310	48	15.5
Pan American	705	60	8.5
TWA	173	74	42
Total	2,164	494	—

The Port Authority's rules, as originally set up, first prescribed a mandatory runway for jet takeoffs to get them over water instead of nearby communities. When cross wind component ruled that runway out, other runways were to be used under specified operating procedures, including a 1,200 ft. minimum altitude over communities, takeoff power settings, flap settings, rate of climb, power cutbacks and designated turns. These detailed operating rules have been proven impracticable by actual experience, and the Port Authority has changed its conformance criteria. The runway priority remains, but after that it is up to the airlines as long as the noise level is within the allowable range—i.e., not more than 112 "perceived noise decibels" on the ground in the communities involved.

This perceived decibel standard is designed to measure noise as the human ear does rather than as a mechanical device would. Developed by Bolt, Beranek and Newman, acoustical consultants, it is said to introduce the human annoyance factor into a noise-measurement formula. By this standard, a jet gives a higher reading than a piston plane because the jet noise is higher in frequency and hence more annoying to the human ear.

How Formula Works

For example, a jet at about 1,000 ft. over a community might bring the reading on a straight decibel meter to 100 db. Applying the perceived decibel formula brings the figure to about 112 db. A piston aircraft would be at a lower altitude than the jet, say 700 ft., to give the straight reading of 100 db. Adjustments would bring the piston perceived reading to about 106 db. The difference is due to the frequencies of noise involved, with the jet noise falling higher on the frequency scale. The formula is complicated and the above example is typical rather than exact.

Some airline officials have unofficially derided the perceived decibel measurements, but the Port Authority says the

Lockheed Assembles Northwest's First Electra

First of 10 Lockheed Electra turboprop transports for Northwest Orient Airlines is almost completed and is expected to be delivered July 15. All 10 are planned to be in service this year. Northwest will deliver nine Boeing Stratocruisers to Lockheed on a trade-in or sale basis. Northwest's Electras will carry 1,060 more gallons of fuel than earlier Electras; total capacity will be 6,420 gal.

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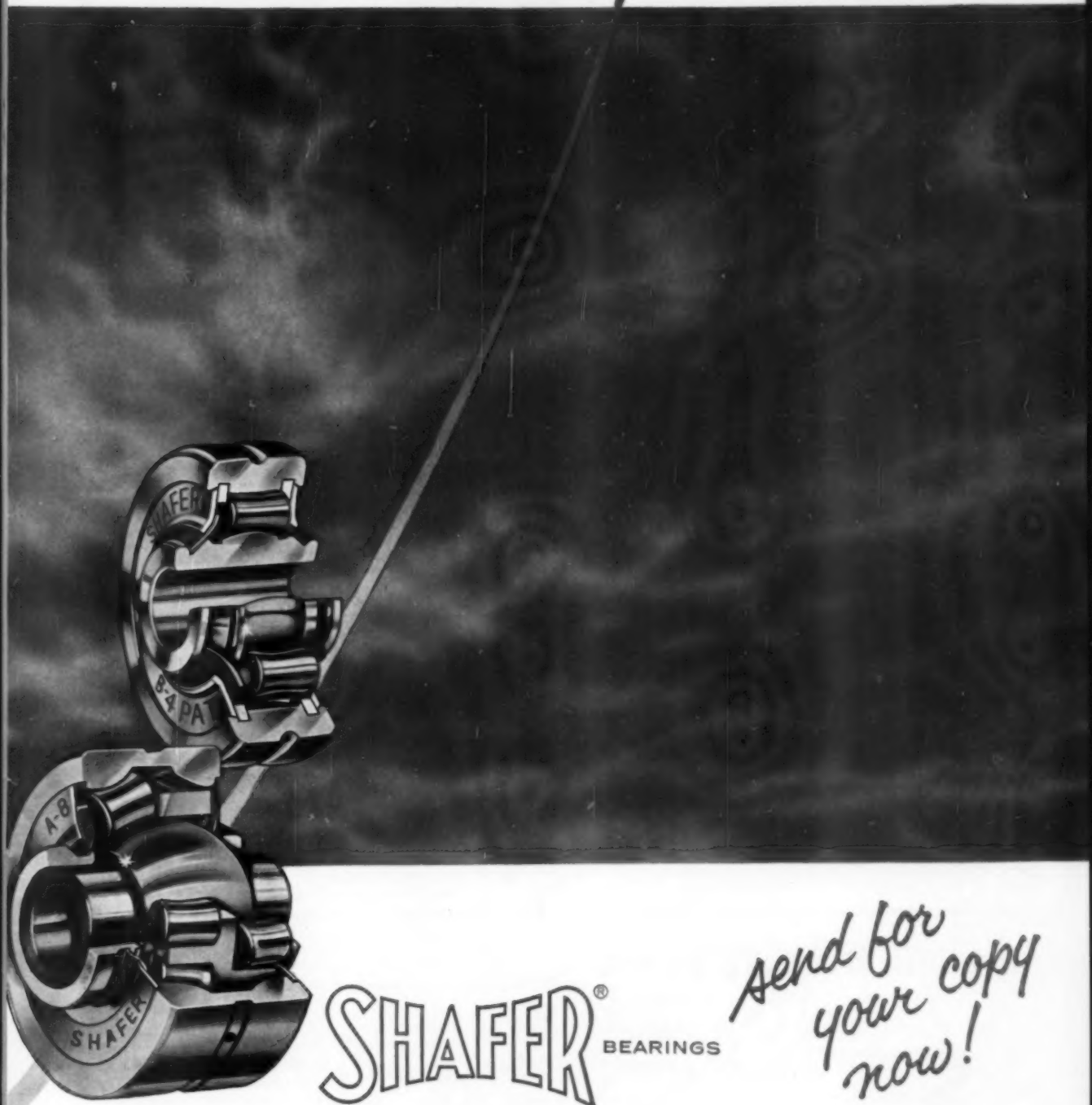

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standard is being accepted by acoustic experts, aircraft manufacturers and others concerned with noise measurement.

Monitoring System

The Port Authority monitors jet takeoffs by sending a sound crew in a station wagon carrying monitoring equipment to check points off the ends of runways near neighboring communities. The crew, advised daily of planned airline training and scheduled jet takeoffs, sets up its microphone and records noise levels. The tape goes to a room in the control tower where a spectrum analysis is made and the perceived noise formula applied. The information, along with wind data, is sent to the Port Authority experts who evaluate it and advise the airlines daily as to how they have conformed. Violations occur when the wrong runway is used and/or the reading exceeds 112 perceived noise decibels.

The Port Authority, in its latest (June 5) letter to community leaders involved in the Idlewild noise problem, reported that all jet operators had improved their conformance records in May compared with April, when Runway 25 was out of service for correction of "certain surface irregularities." But American and TWA "continued to make poor records of conformance . . . for the period from the beginning of their jet operations through May 31."

Aerolineas and BOAC operate the de Havilland Comet 4 and have little problem with the procedures with that smaller and lighter aircraft. National is out of the jet business temporarily, its leased 707-120s having gone back to Pan American, so only three airlines actually have a major problem this summer.

'Cooperation Where Possible'

Both American and TWA adhere to an official line of "cooperation where possible" with the Port Authority, and both are aware of the community noise problem. Cooperation "where possible" officially means when consistent with safety, but it seems clear that the unofficial reading is "when consistent with safety and economy." Neither airline apparently is going to sacrifice payload or make a fuel stop to satisfy the Port Authority rules.

Pan American, on the other hand, says it has been bending over backward to follow the procedures and the record would bear this out.

Federal Aviation Agency's regional air carrier safety office at Idlewild has set up a committee within its own organization to explore possible alternative means of handling the noise problem. Its object will be to find some way of keeping the community annoyance down without penalizing the critical economics of the expensive and unpaid-for jet transports.

The regional FAA office recently instructed American Airlines to remove from its jet flight manuals the portion dealing with minimum sound takeoff patterns. American's pilot training did not incorporate the procedures spelled out in the manual, and FAA gave the airline its choice of removing them from the manual or making the training consistent with them. American took them out. In its letter to American on the subject, FAA said no airport management can impose any procedure that might detract from maximum safety, and that American should advise FAA of all restrictions imposed anywhere in its system by airport managements.

Meanwhile the Port Authority says it is more firmly convinced than ever that the jet noise problem is serious at major terminals around the world.

Community complaints at Idlewild, the Port Authority says, are of a different kind now. Jet complaints come more often directly to the agency, from community leaders who felt that the Port Authority's attitude toward jet operation would protect them from excess noise, but who now are disappointed.

The complaints are difficult to meas-

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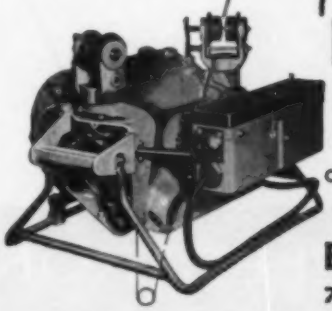

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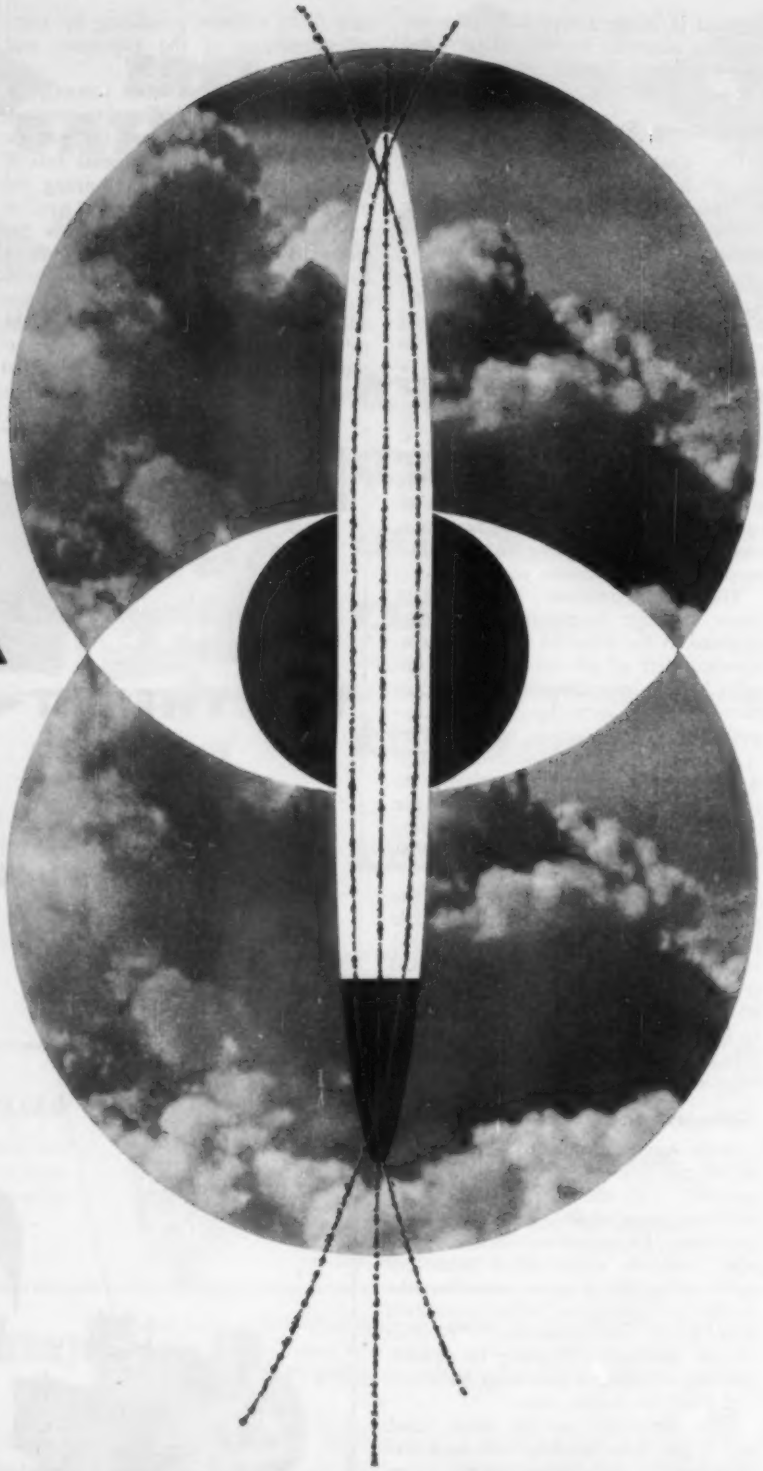

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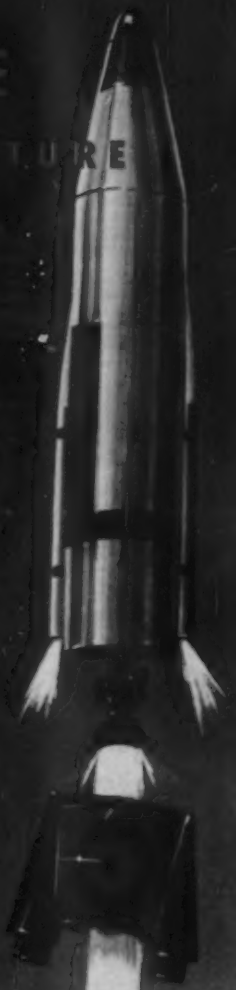

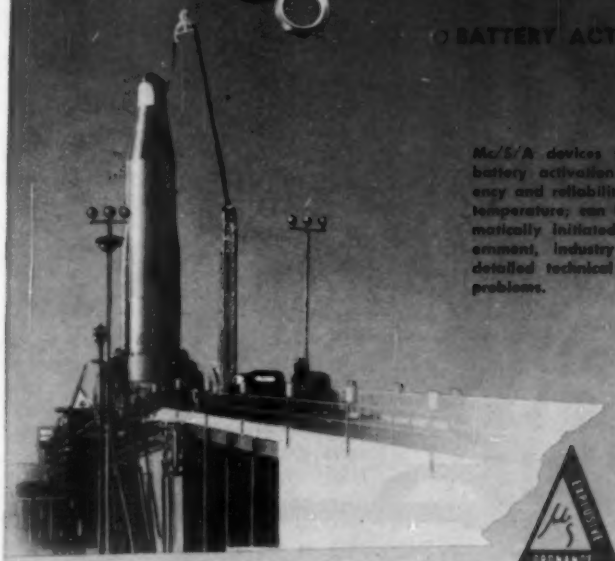

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ure in terms of volume. The Port Authority prefers not to provide figures on the number of complaints, and National Air Transport Coordinating Committee, aviation industry local anti-noise organization, qualifies the statistics accumulated at its New York complaint center.

"Our complaint center does not receive all aircraft noise complaints," NATCC says. "Many people prefer to register their complaints with various types of civic organizations or with their local law enforcement agencies and/or with their political leaders. Others complain to government agencies, the airport operator or to individual airlines."

NATCC's records show a total of 61 complaints concerning Idlewild operations from April 1 through May 7, 1958. Total for the same period this year was 101 complaints, of which 28 were the result of 956 turbojet operations. "We have yet to experience a volume of scheduled turbojet operations during hot weather," NATCC notes.

Arthur J. Fallon, Port Authority Deputy Director of Aviation, told AVIATION WEEK he believes the airlines are going through a phase of getting used to their jets and that the situation will improve as techniques are perfected.

"I can't believe this thing will go on," Fallon said. "We are convinced that the airlines in the final analysis are going to be with us on this . . . no responsible airline will take a public-be-damned attitude over a long period of time . . . we're doing our best to explain over and over again to the airlines the seriousness of this thing."

PanAm Expands Its Hotel Subsidiary

New York—Pan American's hotel operation may be doubled within the next two or three years in an expansion program designed to meet part of the need for more facilities to handle jet-age tourists and business travelers.

Now involved in operating 15 hotels in Latin America and the Caribbean area, Intercontinental Hotel Corp., a wholly-owned subsidiary of the airline, is looking at sites in large cities around the world and expects to begin expanding in Europe and the Far East. The company already has an interest in a hotel at Beirut, which has been under construction on and off for four years but has been delayed by political and economic problems. There have been reports that Intercontinental Hotel Corp. was negotiating for a hotel in Vienna, but the company says nothing definite has been worked out in that city.

Basically, Intercontinental Hotel Corp. provides technical aid in plan-

Texas Instruments roof prism—viewer for photographic system used in the Douglas A3D-2P—helped photo map the landing flight path for North American's X-15

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Your request for detailed information on the Canadair-Convair 540 will receive our immediate attention: contact the Director of Commercial Sales, P. O. Box 6087, Montreal.

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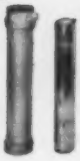

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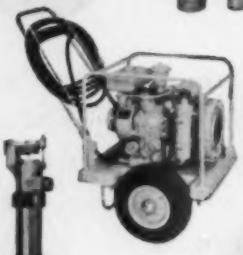

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ning, constructing, financing and managing hotels in areas served by Pan American. Most of the arrangements are through leases or management contracts, but the hotel company owns stock in all the hotels and a controlling interest in four of them. Last year, Intercontinental Hotel Corp.'s net profit after taxes was $220,000. Earnings were adversely affected by political conditions in the Caribbean. In 1957, profit was held to $243,000 by initial expenses in opening several new hotels. The 1956 profit was $497,000.

Two new Intercontinental Hotel Corp. hotel interests were completed last year, one at San Juan, Puerto Rico, and the other at San Salvador, El Salvador. In addition to the Beirut facility, a hotel at Ponce, Puerto Rico, is still under construction. Total assessed valuation of the company's hotels exceeds $64 million.

Pan American's hotel corporation was set up in 1946 and its first hotel, the Grande in Belen, Brazil, was opened in 1948. According to Intercontinental Hotel, Pan American studies showed a pressing postwar need for hotel facilities in South America but existing hotel operators were reluctant to get started.

Provision of such needed facilities stimulates air travel, Intercontinental Hotel has found. As an example, the company's Hotel Tequendama, in Bogota, Colombia, was started in 1953. In the year after its completion, the number of international air passengers through the city more than doubled. Business at this hotel now runs some $4 million a year and the hotel is being expanded to a 615-room capacity.

The hotel corporation is under the over-all supervision of Pan American Vice President Roger Lewis, but only its director of public relations is a Pan American employe. There are about 5,000 employes in the corporation. About half the managers in its hotels are U. S. citizens.

Financing is one of the uncertainties of Intercontinental Hotel's expansion plans, according to Richard E. S. Deichler, executive vice president. Political troubles are of a "transitory" nature, Deichler told AVIATION WEEK.

Financing comes partly through local governments, through local financial groups, and through Intercontinental Hotel Corp.

In many parts of the world, Deichler pointed out, tourist accommodations are poor or non-existent. Since the jet transports will leave no really out-of-the-way places, facilities will have to be developed to accommodate tourists looking for new spots. And advancing economic development of many countries will also bring a need for accommodating more business travelers.

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Riddle Argosy Makes First Flight

Armstrong Whitworth AW 650 Argosy turboprop freighter, first of four ordered by Riddle Airlines (AW April 6, p. 43), makes its maiden flight at Leicestershire, England. Aircraft is powered by four Rolls-Royce Dart RDa. 7/2 engines delivering 2,100 eshp. each. The Argosy was on display at the Paris Air Show; military version has been adopted by RAF.

Deichler said, will be of 200 rooms or more.

In addition to the hotels mentioned above, Intercontinental Hotel Corp. has interests in hotels in Chile, Curacao, Venezuela, Ciudad Trujillo, Mexico City, Barranquilla (Colombia), Cuba and Uruguay.

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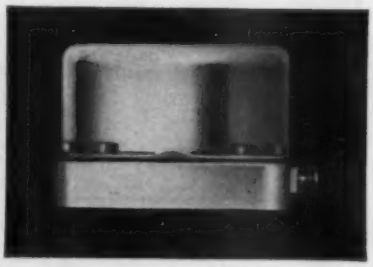

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British Government Rejects Heliport Plan

London—Proposal by Rotorports, Ltd. to build a permanent heliport on the Thames to serve central London has been rejected by the government.

Announcement of the decision declared the site was unsuitable for a heliport because the noise of helicopters arriving and departing would disturb people living on the opposite bank.

"The directors are amazed that the opportunity of providing London with a central heliport at no cost to the public has been turned down," a spokesman for the company said. The decision will be challenged on every available ground and method, he said.

Australian Overseas Air Traffic Increases

Melbourne, Australia—Considerable increase in international passenger traffic, coupled with a comparatively small over-all decline in domestic traffic, marked Australian air transport activities last year, according to Sen. Shane Paltridge, Minister for Civil Aviation.

Australian international airlines carried 88,087 passengers in 1958, an increase of 13.7% over the previous year; total of 419,301,590 passenger miles was a 14.6% boost. Extension of Qantas services through the U.S. to London resulted in a 22% increase in seat miles available.

Domestic traffic dropped 1.1% in 1958, for a total of 2,148,554 passengers. However, preliminary figures for the first quarter of 1959 show domestic traffic up 5.8% in January, 5.5% in February, and 14.5% up in March.

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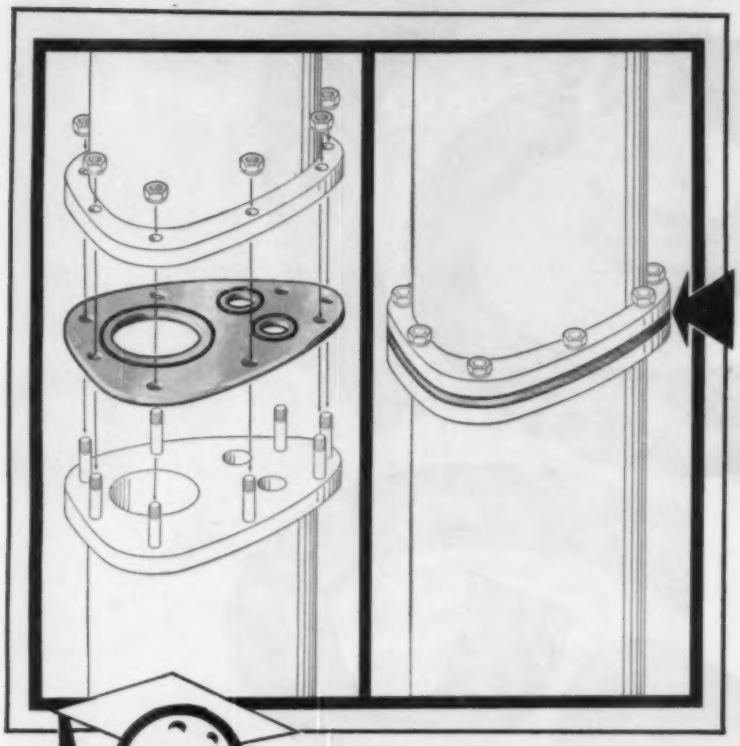

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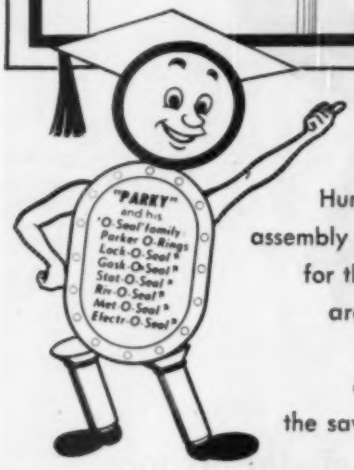

Hundreds of accidents have been caused by seals being left out during assembly or repair, and thousands of production hours have also been lost for the same reason. Just one of the plus values of Gask-O-Seals is that they are practically impossible to leave out because they are inspectable visually after assembly. This can mean many valuable warranty dollars saved, many hours of downtime saved — and it may mean the saving of human lives.

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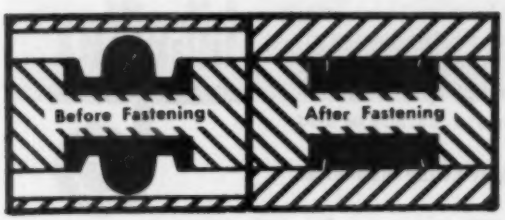

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One of the key parts of this highly sensitive device is the ⅞", 50 ohm, aluminum sheathed Styroflex® coaxial cable that links the 60-foot parabolic reflector to the receivers. The task of carrying missile-to-earth signals from the antenna to the control building demands a low-loss, high frequency cable with a high signal to noise ratio.

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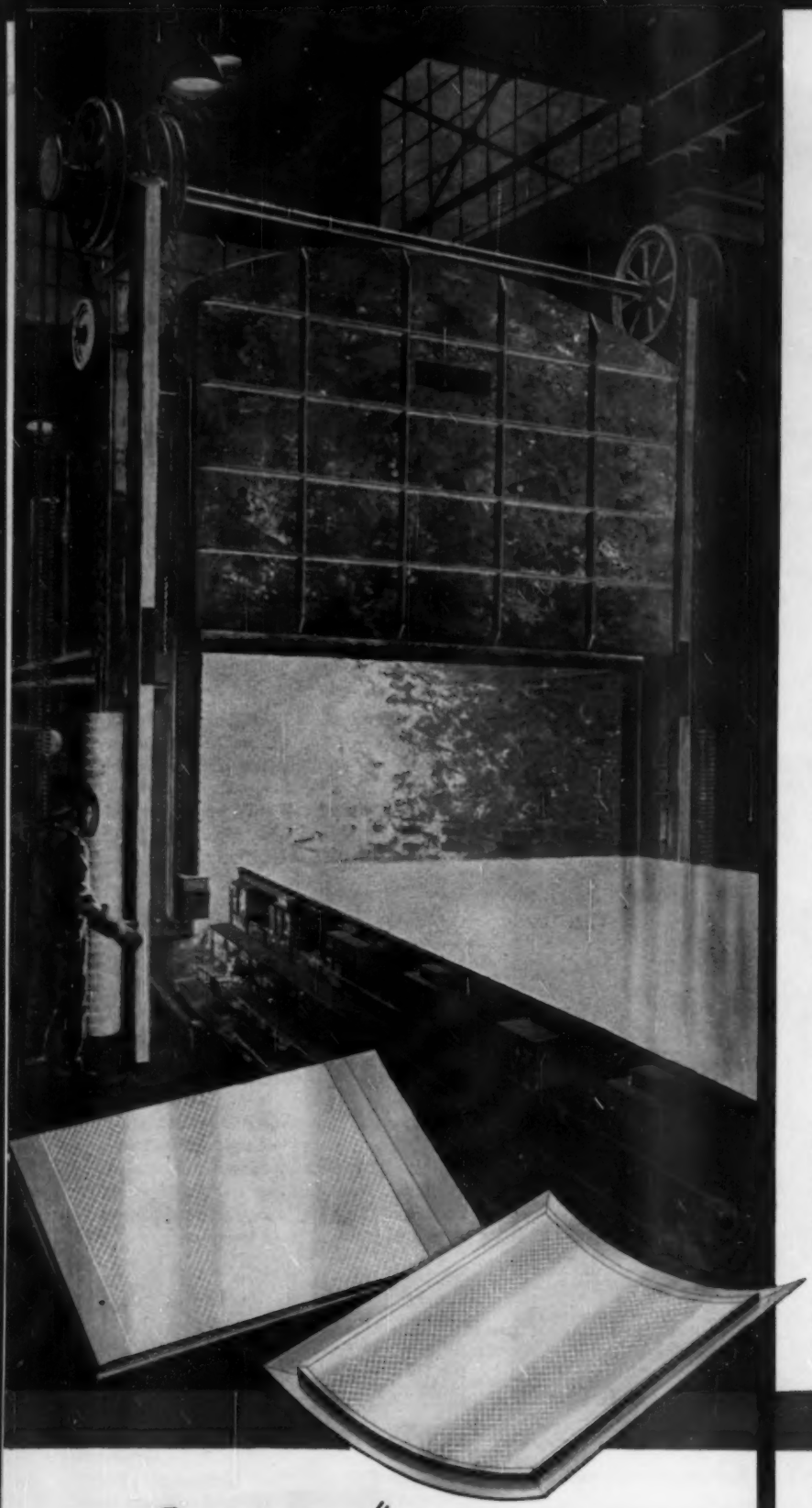

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Already two smaller furnaces are turning out small panels for the high-speed aircraft of the 1960's, as well as other important components requiring high resistance to heat and a very high strength-to-weight ratio (prime characteristics of *Avcomb*). In a few more weeks, the Nashville Division will announce even more production capacity for *Avcomb* through new and less costly processes than those now generally known to industry.

Both the Nashville Division's engineers and its management believe that *Avcomb* stainless-steel honeycomb will be to the aircraft of the future what aluminum is to today's aircraft. And like aluminum in its early years, *Avcomb* will find its way into many new, and as yet unforeseen, applications.

Anticipating *Avcomb's* prospects, Nashville Division engineering already is looking into new and challenging applications for its complete design, tool, and build capability for stainless-steel honeycomb. Several such applications now are under investigation. They range over a broad area, from armorclad structures for military vehicles to air-droppable buoys.

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Rocket-Jet Mach 3 Transport Proposed

By Glenn Garrison

St. Louis—Rockets, ramjets and two-stage vehicles are practical possibilities for supersonic commercial transports, members of the American Society of Mechanical Engineers were told at their semiannual meeting here last week.

Among the less conventional approaches to high Mach number airline operation proposed at ASME's aviation sessions were:

- **Use of a 150,000-lb. thrust** liquid propellant rocket in combination with two afterburning turbojet engines for takeoff, climb and acceleration of the supersonic transport. Rocketdyne Division of North American Aviation said the rocket engine might be similar to its S-3, two of which are used in the first stage of the Atlas intercontinental ballistic missile, or two of the smaller S-4s, one of which is also used in the Atlas, and which would provide about the same amount of thrust.
- **Combination of turbojet** engines for takeoff, and ramjets which would boost the climb and take over entirely during the cruise regime. Advantages would be low operating cost, high reliability, fuel savings and less danger from engine failure at high altitudes.
- **Two-stage system** in which an acceleration aircraft takes a cruise vehicle to altitude. A major advantage claimed for this concept is that it permits a smaller aircraft to carry passengers over long stages at high speeds. Economy and flexibility in airline operation would be expected to result from this approach.

Rocket-Turbojet Combination

Regarding the use of the rocket engines in combination with turbojets, J. M. Cumming, Rocketdyne's program manager small engine systems, told the ASME members that use of air-breathing engines for cruise and the final portion of the supersonic flight appears optimum for the present state of development. But for climb and rapid acceleration to cruise speed, rocket engines would be advantageous. Cumming cited his company's development of aircraft rocket engines under a Navy program, including the AR-1, which significantly boosted the speed and altitude performance of a North American FJ-4F aircraft in flight tests.

Use of ramjet engines for supersonic cruise would save 20% in size and direct operating cost over the straight turbojet, according to J. F. Drake and R. T. de Vault of Marquardt Aircraft Co. Design of a transport with only one type of powerplant to do the three jobs required during takeoff, transonic acceleration and cruise involves severe compromises, the Marquardt officials said.

Takeoff weight of a Mach 3 transport with 140-passenger capacity and 3,500 naut. mi. range would be about 20% less with the turbojet-ramjet combination than with the single type of powerplant, in terms of fuel weight. The ramjet engines would save 5% of gross takeoff weight, more than offsetting their own weight which would add 2% to the gross. Since payload in this aircraft is only 13% of the gross, the 3% gained in fuel weight increases payload and productivity by 20%. And for the same payload, over-all size of the combination aircraft can be 20% less.

A safety advantage claimed for the ramjet cruise engine was that in case of failure in high-speed, high-altitude flight, low-stressed fixed components of the ramjet are not as sensitive to thermal shock as are highly loaded compressors and turbines in the turbojet. And vibration levels are at a minimum in the ramjet. Above Mach 2.5, according to the Marquardt officials, the rotating components in a turbojet are a serious handicap, since high temperatures and stresses produce a hazard and a maintenance problem.

Marquardt-operated facilities may be used for development of supersonic transport engines, the officials said.

The two-stage supersonic transport system was proposed by Applied Science Laboratories, Inc., and in some degree resembles other proposals such as that of Bristol Siddeley Engines, Ltd. (AW May 11, p. 45).

Walter Daskin, Lewis Feldman and Ernest A. Sanlorenzo of Applied Science Laboratories said the two-stage plane would weigh a third less than would a one-stage airplane for the same job and that 42,450 lb. of fuel would be saved over a 3,500 naut. mi. trip.

Operational flexibility was said to be provided by the fact that an airline could use the two-stage system over routes that run long distances between two groups of terminals—for example, between Boston, New York, Philadelphia, Baltimore and Washington on the East Coast and San Diego, Los Angeles, San Francisco and Seattle on the West Coast. Under the concept, a few launching aircraft could shuttle between the terminals in one group, launching a high number of cruise aircraft at fairly rapid frequencies. A similar scheduling arrangement could be made between cities on the Eastern Seaboard and cities in western Europe. This system would offer greater efficiency where moderate traffic provides smaller loads and higher schedule frequencies are appropriate.

One of the cruise vehicle configurations found desirable by the Applied Science experts was a two-abreast seating arrangement with passengers enclosed in a circular pressure vessel with the fuel tanks constituting an annular vessel completely enclosing the passenger compartment. This arrangement was said to provide additional structural integrity.

Cumming of Rocketdyne, however, expressed the view that the two-stage idea involves serious psychological as well as operational problems.

Mach 3 Goal

Discussion of supersonic transport development by the ASME members centered on a Mach 3 speed assumption—as it did earlier this year at an Institute of the Aeronautical Sciences meeting (AW Feb. 2, p. 38).

The consensus of industry thinking therefore seems overwhelmingly in favor of going beyond Mach 2 with the first supersonic transports.

Besides the unconventional approaches to the supersonic problems described above, ASME's discussion touched on more conservative concepts of high Mach number airline transportation—if any such proposals can be called conservative by an industry just beginning to adjust to its radical new subsonic jet equipment.

Among the points discussed were:

- **Powerplant development for** Mach 3 transports has already begun—but many problems remain in coming up with the desired performance, reliability and maintainability for commercial use. One of them, according to G. C. Rapp, of General Electric's jet engine department, is that of engine shutdown at Mach 3 speeds. In that regime, there is very little difference between windmilling and normal operating speed and it will be necessary to reduce the engine speed to maintain the integrity of the engine. This might be accomplished by a blockage of the airflow paths, possibly combined with a braking system through the accessory drive. Rapp believes an afterburning engine will be needed for the supersonic transport, and one of the problems this raises is developing a thrust reverser compatible with the afterburning configuration. One of the biggest problems will be to equip the exhaust system with a sound suppressor to meet airline requirements. Rapp said this is probably the most difficult requirement to meet from the standpoint of complexity and reliability. The compromise in engine performance accepted in subsonic jets to equip them with suppressors is intolerable in Mach 3 design, he said.

• **Environment control** is an increasingly important factor in supersonic transport design. Safely maintaining cabin temperature and pressure at altitudes of 70,000 ft. is a major design field, according to Fred A. Payne of North American Aviation. Loss of pressure can be compensated for by use of ram air cooled through an evaporative water boiler, Payne suggested. A normal window size of 18 in. in diameter is possible with reasonable ram air requirements. Concerning the air traffic control problem when supersonic transports are introduced, Payne pointed out that one bright spot was the fact that supersonic fleets would be smaller than subsonic fleets and also less vulnerable to wind and weather delays because of the altitudes at which they will operate.

STOL-VTOL Development

The varieties of short takeoff and vertical takeoff aircraft under development will narrow to three basic types, in the view of J. B. Nichols, Hiller Aircraft Corp. official. These types are helicopters, tiltwing propeller planes, and turbojet-powered VTOL aircraft.

The helicopter, in Nichols' view, has not filled as broad a role in the transportation picture as originally expected, leaving unfilled the missions requiring higher speeds and transport efficiencies. Of the other types, Nichols said the tiltwing design fills the broadest zone of the spectrum between hovering ability and forward flight ability. With reasonable hovering ability and reasonable transport efficiency, the tiltwing can be applied to many civil transport, business flying and military missions.

The helicopter, in his view, is the most effective for short range transport, flying cranes and various military uses. The turbojet VTOL will serve long range transport and strike missions but because of poor hovering performance must be geared to suitable landing areas.

Some difference of opinion was expressed by Claude E. Leibensberger, Bell Helicopter engineer, who said tests of Bell's XV-3 tilting rotorprop has proved it a practical design for both helicopter and airplane configurations.

Leibensberger reported that 14 full conversions with the XV-3 have been made by the Bell test pilot and three conversions by an Air Force test pilot. The conversions have been made in steps and continuously at indicated airspeeds between 90 and 110 kt. and at altitudes from 3,000 to 10,000 ft. The time required for a continuous conversion is 12 sec. The first complete in-flight gear-shift cycle with the aircraft was completed in April. An appreciable loss of altitude accompanied the complete initial shift cycle, but this will be reduced by improved technique, and installation of free turbine type engines will provide an altitude increase as rotor rpm. is decreased.

The Bell official said control and stability of the XV-3 during forward flight and in normal maneuvers at airspeeds greater than 25-50 kt. are satisfactory and positive. During hovering and low-speed flight, however, additional control and improved stability are desirable for any future design.

Durfee Cites Heavy CAB Workload

By Ford Eastman

Washington—Enactment of legislation to increase Civil Aeronautics Board membership to ease the workload was urged by James R. Durfee, CAB chairman, while testifying before the House Special Committee on Legislative Oversight last week.

In a panel discussion concerning administrative process problems before the committee, Durfee said he strongly felt the present five-man board should be increased to seven or nine members.

"By deciding virtually every substantive matter personally," Durfee said, "the members are facing an almost impossible workload—and the Board has a very difficult time operating with even a bare quorum of three whenever any members are delegated to international negotiations, major accident hearings, conferences with other agencies, or even when illnesses strike."

He said the Board is able to discharge its duties only by extensive reliance on liaison among members conducted through their personal assistants and by extensive use of short-cut procedures.

Rep. Oren Harris (D.-Ark.) committee chairman, scheduled the discussions for the purpose of gathering views on regulatory agencies' problems and what legislation, if any, is required to overcome problems and increases the effectiveness of the agencies. Panel members, besides Durfee, were members of the CAB staff, airline representatives and practicing airline attorneys.

Topics for discussion were:

• **What legislative or administrative** measures have been or should be taken to preclude attempts to influence commission members or employes by means which do not afford a fair opportunity to interested persons affected by the action to present their case?

• **What is the role** of hearing examiners, their present strength and weaknesses, and what measures should be taken to increase their stature and effectiveness?

• **What is the role of commissioners** and their immediate staffs and agency staffs and the division of responsibilities and what legislative measures, if any, are needed?

• **What changes are needed** in the existing statutory provisions relating to substance or procedure to enable the commissions to cope with the increasingly enormous volume of business coming before them?

A major portion of the discussion centered around the topic on what measures should be taken to preclude attempts to influence commission members or employes. Airline attorneys blamed Congress itself for much of the "unfair pressure" imposed upon the Board.

Bitter complaints were registered with the committee about congressmen and senators who appear in behalf of interested parties at oral arguments before the CAB without prior notice to the opposing side and with no time limit set on statements.

Suggestions offered by panelists included:

• **Board members be given freedom** from seeking reappointment by increasing the present six-year term to 10 or more and that they be barred from reappointment. In addition to longer terms, better salaries and a good pension should be provided in an effort to attract high quality persons.

• **All private communications** between the staff and the Board and between interested parties and the Board be made a part of the public record and the case decided on the basis of the complete record. Currently, communications from outside the Board urging certain action in any one case are placed in the Board's public files, but are not considered in the decision or made a part of the record.

• **More hearing examiners** should be appointed and they should have technical assistants, pay should be increased and higher standards set for the selection of examiners.

• **Board should be given** the power to impose civil penalties for violation of economic regulatory provisions of the Civil Aeronautics Act to permit a better opportunity to tailor enforcement to fit the nature of the violation.

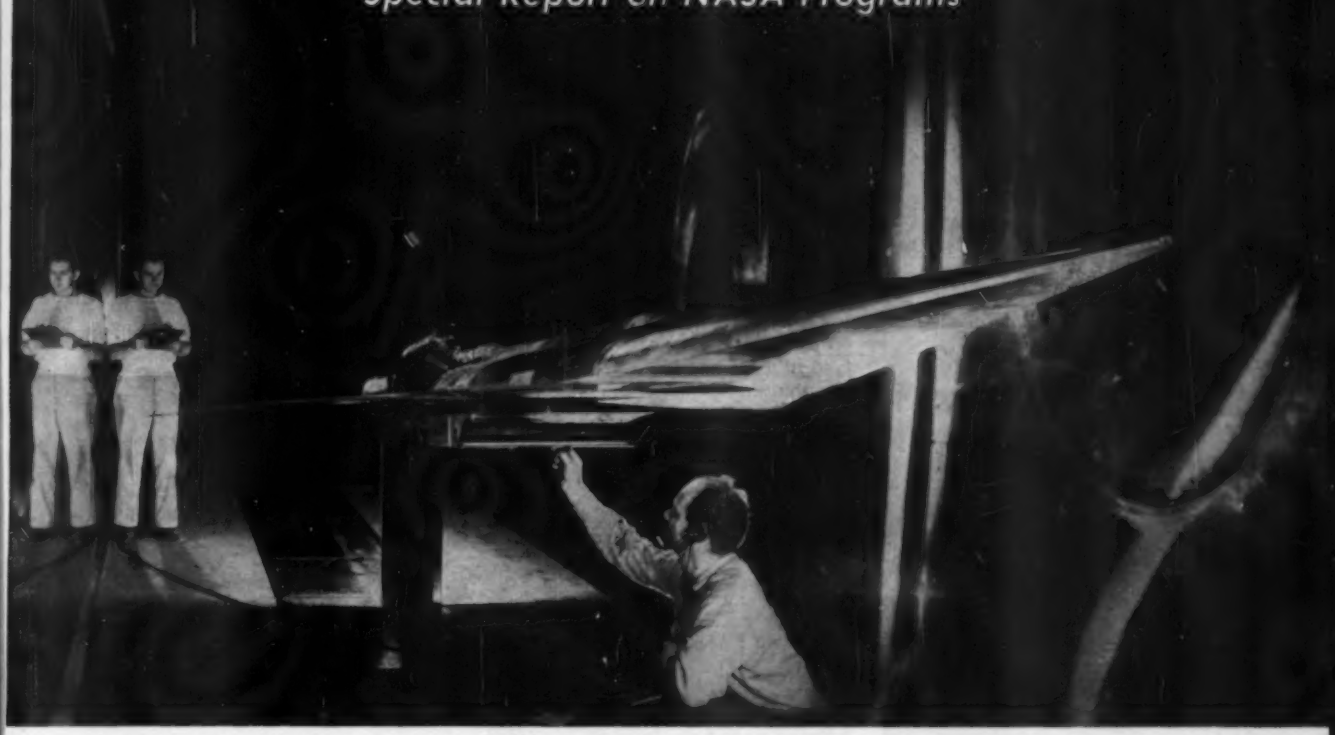
• **Board should be given** authority to eliminate the requirement for a hearing on certain cases involving relatively simple transactions where a hearing is not required in the public interest.

• **Air carriers should be exempt** from filing contracts and agreements of a routine and minor nature such as a joint use of a public address system at an airport or joint use of a piece of ramp equipment.

• **Modify and clarify** the provision of the Act relating to the Board's exemption powers so that exemption applications could be handled more speedily and with less expenditure of manpower.

Next Decade in Space

Special Report on NASA Programs



BOOST-GLIDE aircraft for flight up to orbital speeds typifies foundation laid by National Advisory Committee for Aeronautics for space projects of its successor, National Aeronautics and Space Administration. Model, minus vertical tail, is prepared for test in Lewis Research Center propulsion wind tunnel. Some models of such craft may have flat tops, fuselage beneath.

NASA Leads U.S. Venture Into Space

Man is standing at an intellectual vantage point rare in his history, from which he can foresee revolutionary changes that have not yet taken place.

Harnessing the energy necessary to take his measuring instruments and later himself from his planet into space has opened a field of exploration so vast that his estimate of its potentialities already is expanding in the way the universe itself is thought to expand.

The solar system has become a laboratory where new knowledge no longer is the subject of imagination but of discovery. The universe, long a realm of operations for men's minds, will become a realm of operations at least for the mechanical devices that extend man's sensory powers and perhaps for man himself.

The greatest promise offered by this new frontier is the possibility that man may learn how his universe, his solar system, his planet and his life began, and whether life of the same or another sort exists elsewhere in space.

Eventually the execution and particularly the understanding of these explorations and discoveries will involve and effect all men, but the execution must have a more modest beginning.

The two largest nations of the world are engaged in major programs to find, interpret and understand the secrets of nature as they are revealed in the laboratory of space, and to extend the form of life found on earth to other planets.

This undertaking in the United States is being led by the National Aeronautics and Space Administration in the hope that the exploration of space can remain a peaceful one. In case it cannot, the program is closely related to and supplemented by military programs.

The U. S. space program has become a truly national one directly involving thousands of persons in all scientific and technical disciplines, in the professions of education, law and government, in rapidly growing portions of business and industry, and indirectly involving millions through the support of its citizens.

Immediate goals of this program are to learn more about the earth, the atmosphere that makes life possible; earth's natural satellite, the moon; the closer planets, and whether man can exist in space.

Ultimate goals are to learn and understand all there is to know and understand about mankind and his environment and their origins and destinies. If these goals are unattainable, they seem far less so than they did even a decade ago, and they seem at least likely enough of attainment that a great effort is being put into pursuing them.

Programs, Plans, Goals

Administrator T. Keith Glennan has said that NASA's work can be divided roughly into programs, long-range plans and objectives. Its programs are mapped out somewhat in detail for the next three years, since considerable work already has gone into preparation of the Fiscal 1961 budget, which will carry the agency's activities through June of 1962.

Long-range plans are evident in out-

Tentative Vehicle Launching Schedule

	FY 1959	FY 1960	FY 1961
Scientific satellites	6	8	3
Lunar probes	1	2	2
Space probes	1	4	1
Meteorological satellite	1	2	2
Communications satellite	1	1	3
Test vehicles	1	4	5
Totals	11	21	16

line form in the 10-year national space booster program. Even excluding the probability that nuclear power and possibly even controlled fusion power will be available by the end of a decade, the booster program foresees landing of manned spacecraft on the moon.

Predictions of the future based on projections of technological progress often have turned out to be over-optimistic about nearer events and quite conservative about what would be achieved over a long period of time.

Whether man will reach Mars or Venus by the end of a decade is a matter for speculation. Study and planning already under way at NASA is based, however, on belief that he will eventually. Dr. Hugh L. Dryden, deputy administrator, has said that "as we master the required technology, we will send an expedition to the moon and later on to Mars, to Venus, and to more distant reaches of the solar system."

Scientific Objectives

Scientific objectives of the NASA program—which, aside from immediate military and political considerations—are the really important reasons for the program's existence, have been quite clearly spelled out. They are as ambitious as man's curiosity demands that they be, and they will be pursued for many decades to come.

NASA uses the term "space science" as a shorthand expression for scientific investigations carried out in space by means of sounding rockets, space satellites and space probes.

It has divided its space sciences into seven basic areas for convenience, although they obviously are overlapping and interrelated. These are atmospheres, ionospheres, energetic particles, electric and magnetic fields, gravitational fields, astronomy and biosciences.

Its programs for investigating these areas are organized a little differently, roughly by the types of tools that will be used to explore the scientific mysteries. A brief look at this second type of breakdown illustrates the direction NASA is taking and indicates the kinds of timetables involved:

• **Space boosters.** Beyond the intermediate vehicles such as the Juno II, Thor-Able, Atlas-Able and Thor-Delta, NASA has begun work on boosters that will be the workhorses of the space program for the next several years. They include the Vega, which will cost $91.6 million over the next four fiscal years, including 1960; and the Centaur, which will cost $95.5 million over the same four years. Vega's missions will include hard landings on the moon and orbiting of a two-man space laboratory. Centaur, an advanced man-carrying vehicle, will be fired in 1961 and also will launch communications satellites and permit soft landings on the moon.

Still further along are the 1.5-million lb. thrust engine, some four years away, that will permit manned lunar landings and large, orbiting space laboratories. Somewhere beyond that, estimated at eight to 10 years off, is the nuclear rocket engine for which NASA is providing $8 million in Fiscal 1960 and the Atomic Energy Commission, $46.3 million in Fiscal 1959 and 1960. Ion and plasma propulsion for use from earth orbits may precede the development of useful nuclear engines.

• **Sounding rockets.** In addition to planning to fire some 100 sounding rockets in Fiscal 1960 and a like number the next year, NASA is seeking to develop a vehicle cheaper than the solid-rocket Scout, for trips out to several thousand miles. Sounding rockets already have permitted an improvement by a factor of three in the forecasts of what short-wave frequencies will be usable for radio communications.

• **Scientific satellites.** This category includes development of an orbiting astronomical observatory and an atomic clock payload to test a part of the general theory of relativity. Previous discoveries made with this type of investigating tool include discovery of the Van Allen radiation belts and discovery that the air above 200 mi. is many times as thick as had been believed, which means that spacecraft will require more thrust to maneuver in this region.

• **Lunar probes.** Three are to be launched in Fiscal 1960, with two intended to impact on the moon and the third intended to orbit a few hundred miles above the surface. Soft landings are scheduled for 1961, to put the first small extraterrestrial observatory on the moon. The data obtained will lead directly to design of vehicles for manned landings.

• **Deep space probes.** Two of these, scheduled for late Fiscal 1959, probably will go over into Fiscal 1960. The 1960 budget allows for preparation of two more probes to be fired in Fiscal 1961. At least one will be fired toward Venus.

• **Meteorological satellites.** Two attempts will be made by mid-summer to launch a heat balance satellite. More sophisticated television weather satellites, called Tiros and inherited from Defense Department, are to be launched, one by the end of the year and another next spring.

In 1961, two launchings of a prototype operational weather satellite into a 700-mi. polar orbit, using the Vega vehicle, are planned. This project will consume over two-thirds of the Fiscal 1960 meterological satellite funds.

Steps beyond this are radar satellites and experiments leading to an ultimate operating system that would use six satellites in 700-mi. polar orbits and four in 22,300-mi. "stationary" orbits.

• **Communications satellites.** By the end of 1959, a 100-ft. inflatable passive reflector satellite is to be launched, permitting radio bounce experiments between the east and the west coasts.

In 1960 and 1961, three more launches are planned. One will carry a number of satellites to an altitude of 2,500 mi. This probably will be a Vega carrying 10 reflectors.

• **Manned space flight.** Beyond the top-priority Mercury manned capsule are plans for a two-man capsule, an orbiting six-man laboratory, and studies of still more advanced vehicles. Because of the urgency of Mercury and the questions it may answer, only a small percentage of the next budget has been reserved for studies of future manned craft.

Objectives of the NASA program range far beyond those projects that are near enough to have timetables and vehicles associated with them. The vitally important space sciences program sometimes goes unnoticed in the midst of more dramatic satellite and space probe launchings, but it is the very broadest kind of framework within which all NASA's other space work is done.

Dr. Dryden has expressed the implications of this search for knowledge this way:

"The most profound impact of space knowledge will be on the basic sciences of astronomy and geophysics, for space vehicles make possible direct experimental measurements in space at the sites of the phenomena under study.

"Through advance in these sciences we will gain a deeper understanding of the universe in which we live, including our earth and nearby space, the moon and planets, interplanetary space and distant galaxies.

"This deeper understanding and knowledge will bring the power to predict, to direct and to control the forces of nature and our own destiny."

Engines Hold Key to Space Timetables

Five new liquid fuel rocket engines and modifications of two existing engines of the same type form the backbone of the national space program as now planned by the National Aeronautics and Space Administration. All very large space vehicles scheduled to be launched by NASA in the next five to six years and probably within the next 10 years will be powered by combinations of these seven engines.

Extreme importance of these boosters revolves around the fact that they are the longest lead time items required for the space program. Their rapid and successful development is vital if the U. S. is to have any hope of surpassing Soviet Russia in payload capacity in the near future or of sending manned vehicles to the moon and beyond.

The efficiency of these boosters and vehicles, which are tailored for specific tasks, will be much higher than that of the modified military rockets now in use. They will reduce the vehicle cost required to send a pound of payload into orbit or outside of the earth's gravity by as much as 20 to 30 times.

Soviet Propulsion Lead

NASA estimates that it will be about two years before this new engine program will bring the nation's space launching capability to the level the Russians demonstrated last January with Mechta. But U. S. booster power will jump rapidly after that point if the present schedule can be maintained. Depending on Russian progress, there will then be some chance of leap-frogging ahead in space competition.

Several other projects in the NASA propulsion program are involved either with solid fuel rockets or with far more advanced powerplants that still are in the research stage. Solid propellant work presently is concentrated in Project Scout which is now in its initial phases. Its purpose is to develop a four-stage vehicle of improved rockets that can send 150 lb. of instruments into a 300-mi. orbit or 100 lb. to an altitude of about 5,000 mi. Scout will be the most inexpensive rocket system for space work in the U. S. inventory.

Large nuclear powered rockets and electrical low-thrust, high specific impulse systems such as ion and plasma rockets are in an advanced study stage.

Present opinion is that ion rockets will reach development first, with flight test possibly taking place as early as four years from now.

The seven liquid fuel engines that are due to receive the bulk of NASA development funds over the next few years are:

• **6,000-lb. thrust storable** fuel engine being developed by NASA's Jet Propulsion Laboratory. Although development times are diffcult to estimate accurately, NASA now expects this engine to be available about mid-1960.

• **15,000-lb. thrust engine** using liquid hydrogen and oxygen propellants. This is being developed by Pratt & Whitney Division of United Aircraft Corp. Operational capability is expected in 1961.

• **20,000-lb. thrust storable** fuel engine which is still in the study phase. Scheduled to be available in mid-1963, this engine may use a pumped propellant system rather than the pressurized tanks of the 6,000-lb. thrust engine.

• **80,000-lb. thrust liquid hydrogen** and oxygen engine which has been under research and development contract for about a year. It is scheduled to be available in the first quarter of 1963.

• **1.5 million-lb. thrust** single chamber engine using kerosene and liquid oxygen propellants. This engine is being developed by Rocketdyne Division of North American Aviation, Inc., and is scheduled to be available in mid-1963. Air Force and Advanced Research Projects Agency originally supported this work.

• **34,000-lb. thrust engine** which is a modification of the first stage engine of the Vanguard satellite launching vehicle. General Electric Co., the contractor for the original engine, will handle the modification. The new engine is scheduled for flight test in mid-1960.

• **190,000-lb. thrust kerosene** and liquid oxygen engine, a modification of the type used currently on intermediate and intercontinental range missiles. Rocketdyne already has supplied the first of these engines for the eight-engine Saturn cluster.

Primary objective in the selection of these particular engines is to provide a family of space vehicles of ever-increasing capacity and reliability. Each vehicle in the family should be adequate for most of the space missions planned during a two to four year period. These missions would encompass satellite work including low and high circular orbits; lunar exploration, planetary exploration and deep space probing.

The general-purpose nature of these

UNTIL new engines are ready, experiments use modified missile boosters or hitch-hike in missile test shots. This Army-Chrysler Jupiter carried monkeys Able and Baker 300-mi. into space.

vehicles would allow them to be used many times and at frequent intervals. As a consequence their reliability, which is the most unbending requirement for space use, would almost inevitably reach a high figure.

This systematic family of new vehicles, the first of which will be ready for use in about one year, will eventually replace two groups of rockets. One, which exists now, includes the Navy-Martin Vanguard, Army-Chrysler Jupiter-C and Juno II, USAF-Space Technology Laboratories Thor-Able and USAF-Lockheed Thor-Hustler. With the exception of the Vanguard all of these vehicles originally had some military background. Most powerful is the Thor-Hustler which uses a Bell Aircraft Corp. Hustler rocket engine, originally designed for a Convair B-58 bomber pod, as a second stage for the Douglas Thor IRBM.

Thor-Hustler is the primary vehicle in the Discoverer satellite series being conducted by the ARPA. This group of boosters, which has borne the brunt of U. S. demands in space created by Sputnik I, has sent seven satellites into orbit and launched three space probes.

The second group of boosters that will be superseded in time by the new family of NASA vehicles are two modifications of the USAF-Convair Atlas missile and one variant of the Thor-Able, all of which will be available within the next year.

One is the two-stage Atlas-Hustler, using the Bell engine for the second stage on the Atlas, which can put 3,000-lb. in a low orbit. The other is the Atlas-Able, which uses the Aerojet second stage of the Vanguard and an Allegany Ballistic Laboratory solid engine mounted on the Atlas to make a three stage vehicle. The last of this group is the Thor-Delta which is the Thor-Able with guidance added in the second stage to allow it to coast for considerable distances after the first stage burns out. Coasting guidance of this type allows the vehicle to place a satellite into a circular orbit of considerable altitude by firing its second stage at the proper angle when maximum altitude is approached. Coasting capability also will be useful for space probe missions. A dozen Deltas have been ordered from Douglas.

Four Basic Vehicles

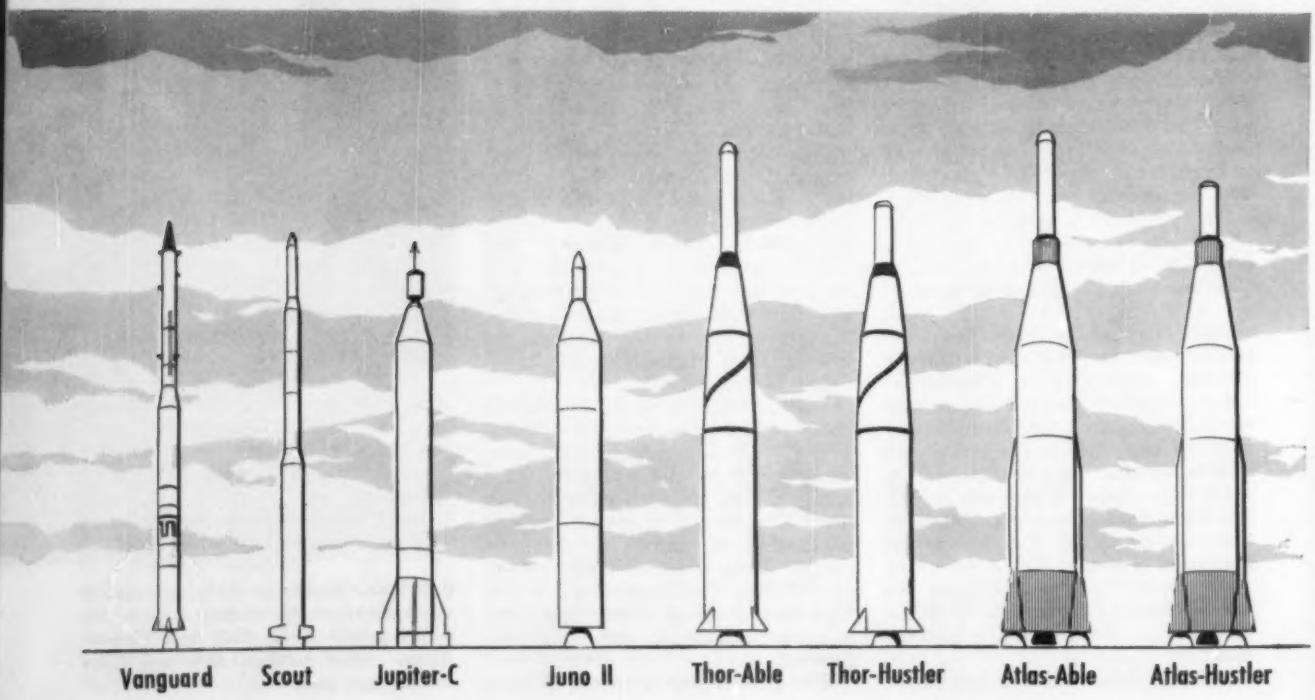
Four vehicles are now being planned by NASA to use the seven basic engines being developed in the new booster program. The first two use Atlas for the first stage, but they will have a much greater payload capacity than the Atlas-Able and Atlas-Hustler because the upper stages are designed especially for the Atlas, so that all stages are properly matched from a weight and power standpoint.

Atlas was chosen for the primary stage of these two vehicles because it is the largest high-time booster assembly available in this country. Its reliability during the last year has been "remarkable" according to the NASA, and it is considered by that agency to be the ideal building block to get great payload capability.

The four advanced vehicles are:

• **Vega.** This vehicle, being developed by Convair Division of General Dynamics Corp., will come in both two- and three-stage versions. The first stage will be a production type Atlas except that the front end will be brought out to a full 10-ft. diam. so that the propellant section will be completely cylindrical. Second stage will be the same diameter. It will be produced with Atlas tooling and will mate with Atlas test and launching equipment. This stage will use the modified GE Vanguard engine. This was the most successful of Vanguard powerplants and it functioned properly on its last six flights. Major modification to this engine is an increase in nozzle length and addition of an ignition system for altitude starting. NASA expects delivery of the first modified engine late this year. The two-stage version will be able to put roughly a 4,000-lb. payload with several men aboard into a 300-mi. orbit for several weeks. This second stage engine will also have a restart capability so that it will burn during two different portions of the flight. This capability is needed to place objects

FAMILY of space vehicles planned by NASA to handle needs for next 10 years is based on use of chemical rockets. All use liquid fuel

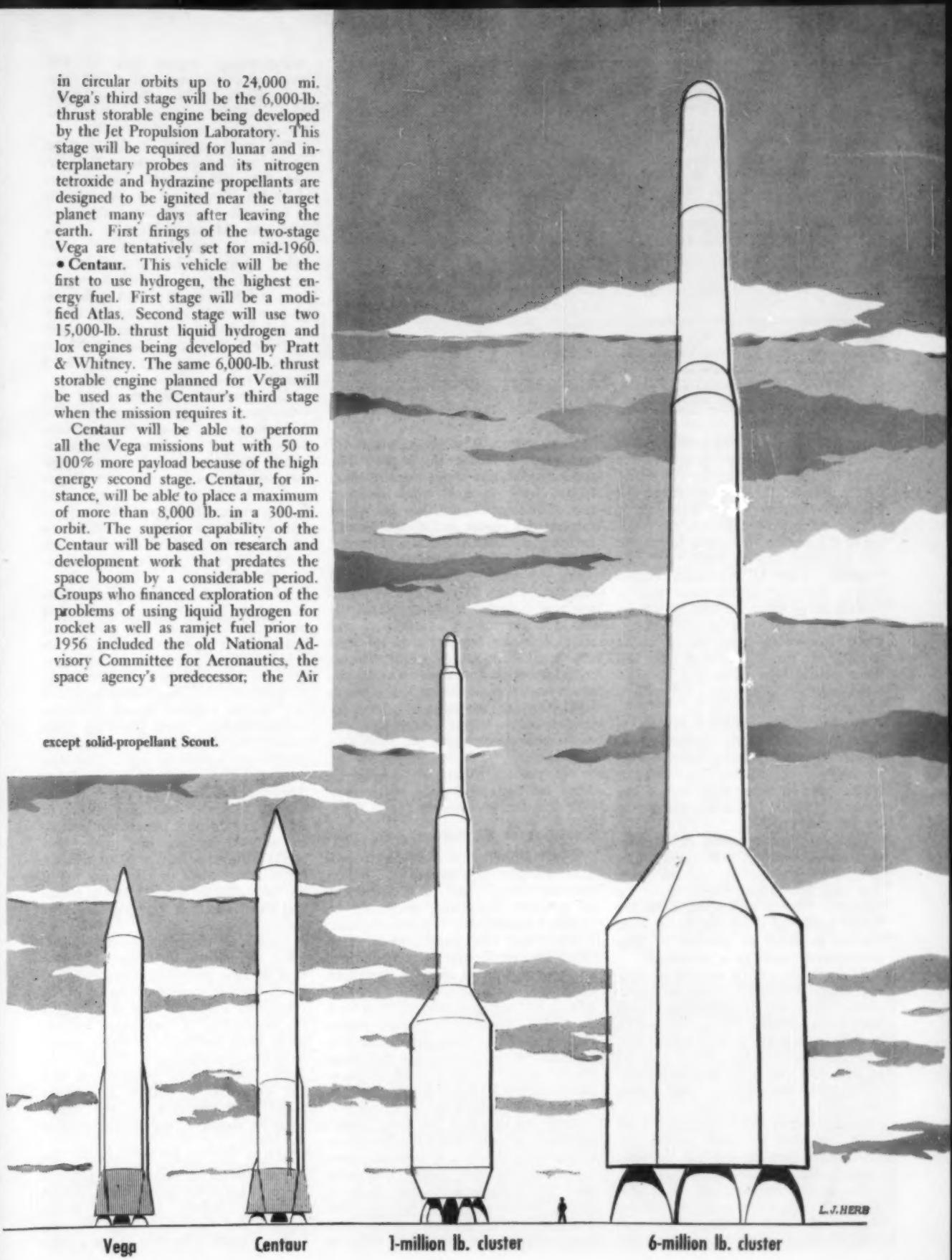


in circular orbits up to 24,000 mi. Vega's third stage will be the 6,000-lb. thrust storable engine being developed by the Jet Propulsion Laboratory. This stage will be required for lunar and interplanetary probes and its nitrogen tetroxide and hydrazine propellants are designed to be ignited near the target planet many days after leaving the earth. First firings of the two-stage Vega are tentatively set for mid-1960.

• **Centaur.** This vehicle will be the first to use hydrogen, the highest energy fuel. First stage will be a modified Atlas. Second stage will use two 15,000-lb. thrust liquid hydrogen and lox engines being developed by Pratt & Whitney. The same 6,000-lb. thrust storable engine planned for Vega will be used as the Centaur's third stage when the mission requires it.

Centaur will be able to perform all the Vega missions but with 50 to 100% more payload because of the high energy second stage. Centaur, for instance, will be able to place a maximum of more than 8,000 lb. in a 300-mi. orbit. The superior capability of the Centaur will be based on research and development work that predates the space boom by a considerable period. Groups who financed exploration of the problems of using liquid hydrogen for rocket as well as ramjet fuel prior to 1956 included the old National Advisory Committee for Aeronautics, the space agency's predecessor; the Air

except solid-propellant Scout.



Lunar Probes and Payloads

Type Mission	Booster Vehicle	Payload
Lunar near-miss	Juno II	15 lb.
Lunar impact	Thor-Delta	100 lb.
Unmanned lunar orbit	Thor-Delta	65 lb.
" " "	Atlas-Hustler	250 lb.
" " "	Vega	900 lb.
Lunar rough-landing	Thor-Delta	50 lb.
" " "	Vega	450 lb.
Lunar soft-landing	Vega	430 lb.
" " "	Atlas-Centaur	730 lb.
" " "	Juno V	1,700 lb.
" " "	Nova	19,900 lb.
Unmanned orbit with instrument return	Atlas-Centaur	275 lb.
" " " " "	Juno V	700 lb.
Lunar soft-landing with return of sample	Juno V	200 lb.
Manned lunar landing and return to earth	Nova	2,100 lb.

Assumes use of additional freight rockets to supply and support men after lunar landing.

Force and the Navy, and several industrial firms. Significant progress was made by 1958 and the Air Force and ARPA initiated the development of the Pratt & Whitney engine. Next July 1, NASA will formally take over the funding of this engine. It expects to fire the first Centaurs early in 1961.

• **Saturn.** First U. S. rocket engine system that will deliver more than 1 million lb. of thrust at take-off will be used as the first stage of this vehicle. Eight Rocketdyne engines of about 190,000 lb. thrust each and nine ballistic missile type tanks will be clustered together to provide a 1.5 million lb. unit.

Work on this clustered booster is the responsibility of the Army Ballistic Missile Agency, operating under the direction of the ARPA. The booster is scheduled to enter flight test before the end of 1960. It is also referred to as the Juno V engine.

Complete configuration of the Saturn vehicle probably will consist of an intercontinental missile second stage plus the two upper stages from the Centaur. This is in keeping with the NASA policy of using the seven basic engines as much as possible to keep development costs to a minimum.

This vehicle will be capable of placing about 30,000 lb. into an orbit around the earth. Missions which have been described for the Saturn include sending five men in a space laboratory into orbit for several months so that they can perform detailed uninterrupted observations and experiments.

• **Nova.** This is the largest of the vehicles definitely included in the current NASA program and it is the only one capable of sending men to the moon and returning them to earth. This first stage will consist of a cluster of four of the 1.5-million lb. thrust, single-chamber units being developed by Rocketdyne. The second stage will be a single 1.5-million lb. engine. The third stage will be about the size of an ICBM but will use liquid hydrogen fuel. The fourth and fifth stages would employ high energy and storable propellant engines which are now included in the booster development program. This five-stage configuration would stand more than 250 ft. high. A seven-stage vehicle also is contemplated. It would make use of advances in the state of the art expected over the next few years. This vehicle would be able to transport two or three men to the moon and return. These seven stages would include the rockets needed for landing on the moon, takeoff from the moon and re-entry into the earth's atmosphere.

For the earth satellite mission, a Nova vehicle would place about 150,000 lb. into a close orbit.

Cost Set at $2 Billion

This ambitious booster vehicle program will cost approximately $2 billion over the next 10 years if it is carried out as presently conceived, according to NASA Administrator T. Keith Glennan.

The Fiscal 1960 budget, which takes effect next week, calls for expenditures of about $3 million on solid propellant rockets, $5 million on high energy propellant rockets, and about $30 million on the 1.5-million lb. thrust single-chamber engine. Total amount already involved in contracting for this large engine is $102 million, and it is expected to cost a total of $200 million to bring it to a useful stage.

The cost of these "building block" engines is so great that considerable attention is being given to possible recovery of the boosters. NASA has budgeted $1.5 million to initiate recovery system studies in Fiscal 1960, and the first goal is to try to have a system that could recover the Atlas skirt with its two first-stage engines from the first Vega vehicles a year and a half from now. Air Force, Army Ballistic Missile Agency, ARPA and industry also are involved in recovery system studies.

Despite the ambitious aims and the money and manpower that will be required to complete such an extensive space booster program, progress already is better than expected in some areas. Maj. Gen. Marvin C. Demler, director of research and development under USAF's Deputy Chief of Staff for Development, recently described progress on the 1.5-million lb. Rocketdyne engine as "rather spectacular," and revealed that the combustion chamber and nozzle had been fired last March at a level of more than 1 million lb. of thrust.

Simultaneous development of the other principal engine parts, such as the turbopumps, the gas generator and controls, is being supervised by Rocketdyne. Facilities to test the components and the complete engine are larger and more extensive than those required by any engine in the past. These facilities are being provided by modification of tests stands at the Rocket Base, Edwards AFB, Calif., plus some new construction there.

The national vehicle program is predicated on the optimistic premise that all five new engines will meet their specifications and complete their development cycles in the alloted time. But provisional plans have been made to cover the hole that would be left if any of the engines should run into serious trouble. These plans are built around the clustering of engines with satisfactory records to replace any that have failed to meet their schedules. Therefore, all the engines will be developed to permit clustering, either to serve as a substitute powerplant unit or to be used for any new stages that might become desirable. Most difficult engines to replace by clustering would be the 6,000-lb. thrust storable model and the 1.5-million lb., single-chamber rocket.

Even if all the engines can be developed successfully, the exact composition of these multistage vehicles is not firmly fixed at present. Tailoring of the vehicle to a specific task or to adjust for availability of production engines could affect the choice of stages as well as technical performance. For instance, NASA officials have pointed out that the clustered 1.5-million lb. engine could be substituted for the single-chamber rocket in the second stage of the Nova.

While this group of engines and vehicles covers the needs of the national space program for several years, NASA testimony before Congress clearly pointed out that even larger boosters and new types of boosters will be needed

in the program's foreseeable future.

Main hope for keeping booster vehicles with very large payloads below Nova's planned gross weight of about 5 million lb. is through nuclear rockets. Such a powerplant would have a specific impulse of about 800 under present plans. This is roughly twice that expected from improved chemical systems. If this performance is reached the nuclear rocket will dramatically reduce the size and complexity of large space vehicles.

A high energy chemical rocket would have to have three stages and weigh one million pounds at takeoff to place a 30,000-lb. payload into a 2,300-mi. orbit. A single-stage nuclear rocket weighing only 200,000 lb. could handle the same task. The balance swings farther in favor of the nuclear system as either payload or distance increase. If the mission were to send a 150,000-lb. gross weight vehicle to Mars from a space station above the earth, the chemical system could deliver 7,500 lb. of payload and could return only 750 lb. to earth. A nuclear system of the same initial weight could support a manned expedition because it could deliver about 55,000 lb. to the Mars orbit and return 25,000 lb. to earth.

Nuclear Rocket Availability

Considerable optimism has been voiced by some NASA, Atomic Energy Commission and industry scientists about operating nuclear rockets being available by 1970, even though the first test firings of a reactor system which resembles that needed for a rocket engine will not occur until later this summer. The AEC is handling the reactor work for the nuclear rocket and NASA is in charge of the development of the pumps, tanks and auxiliary equipment. The first nuclear rocket as now envisioned will use a heat exchanger reactor in place of a combustion chamber to heat the liquid hydrogen propellant before it is exhausted through a conventional nozzle.

Nuclear rockets probably will be reserved for use on large, long distance vehicles because of their cost and the fact that they have a limiting weight below which chemical rockets are more efficient. This weight limit depends on a number of factors such as vehicle construction, mission etc. It arises because present estimates show that a nuclear rocket will be able to produce about 40 lb. of thrust per pound of engine structural weight while good chemical systems yield about 100 lb. of thrust for each pound of engine. Therefore, the nuclear rocket in comparison to chemical engines only begins to become attractive when the saving in propellant weight that it offers is greater than the increase in engine weight that it requires.

Still more efficient propulsion systems from the standpoint of propellant consumption are the electrical systems, now in the research stage at NASA laboratories. These electric engines exhaust their propellants at roughly eight times the velocity of the nuclear rocket and 20 times the velocity of chemical rockets. Therefore they can provide a given thrust with a much smaller amount of propellant than either the nuclear or chemical systems. Since these electric engines require heavy, elaborate generating equipment for their power, their usefulness is a question of whether their total engine weight can be kept below the weight of the propellant that they save for a given mission.

Promise of Electrical Engines

Considerable work has been done in this area in the last two years and it has created strong opinion among cognizant technical personnel that the total weight of the electric engines can be kept low and that they will prove extremely useful in space. No electrical propulsion scheme now nearing fruition would develop enough thrust to lift itself from the ground. It appears now that electric engines cannot be used as the primary powerplant, and will be useful only after a vehicle has been boosted at least to orbital speed.

Two primary types of electric engines are being studied—the ion rocket, in which the propellant is separated into positive and negatively charged particles, and the plasma accelerator, in which the ionized propellant is kept in a neutral plasma state. High exhaust velocities are realized with both engine types because the working fluid is kept away from the walls of the engine either by an electric or a magnetic field so it can be heated to very high temperatures. This eliminates the structural materials problem, which is the limiting factor on the performance of a heat exchanger type of nuclear rocket.

NASA scientists believe that the ion engine can be developed into operational usefulness before the plasma engine. This might occur within the next four years. Engines of this type, producing very small amounts of thrust, may be useful for attitude control on satellites, station keeping for satellites to overcome small amounts of aerodynamic and electrical drag, as well as the primary propulsion system for lunar and planetary probes.

Solid propellant rockets are being considered for use on the large vehicles previously described but at this time they have been brought positively into the NASA program for only one purpose. This purpose is to provide a family of small, highly reliable, inexpensive vehicles that can send instruments into orbit or to probe space out to about 5,000 mi. from the earth.

Four rockets are being developed under this Project Scout program. They can be staged together to perform a variety of missions.

Chance Vought has received a contract to build the Scout airframe and to integrate the four engines into it. These engines, which will have performance superior to the sounding rockets in use today are:

- **First stage**—modified version of early Polaris motor designed by Aerojet-General.
- **Second stage**—an improved Sergeant developed by Thiokol.
- **Third stage**—scaled-up version of the Vanguard third stage engine developed by Hercules Powder Company's Allegany Ballistic Laboratory.
- **Fourth stage**—similar to the present Allegany Vanguard engine.

Payload tests with the Scout system are scheduled to begin in mid-1960 at NASA's Pilotless Aircraft Research Station at Wallops Island, Va. Previous sounding rockets in use in this country reached a speed of about 12,000 mph. with a payload of approximately 25 lb. Scout will send 100 to 150 lbs. to 25,000 mph. and the total vehicle will cost about $500,000. Its cost therefore will be much lower than the military rockets now used for small satellite and ballistic missile test work.

Interplanetary Probes and Payloads

Type mission	Booster Vehicle	Payload
Initial planetary probes	Thor-Able	50 lb.
" " "	Atlas-Able	200 lb.
" " "	Vega	1,300 lb.
Venus, Mars near-miss	Atlas-Hustler	200 lb.
Venus, Mars unmanned orbit	Vega	250 lb.
" " " "	Juno V	900 lb.
" " " "	Nova	15,000 lb.
Venus, Mars atmosphere entry	Vega	1,300 lb.
Solar probe, Jupiter near-miss	Juno V	1,900 lb.
Venus, Mars landing	Juno V	400 lb.
" " "	Nova	4,000 lb.

Manned Orbital Flight Is NASA's Top

Project Mercury is the highest priority program now being conducted by the National Aeronautics and Space Administration. Its objective is to place a man in orbit around the earth at the earliest possible date. NASA officials have described the program as urgent and have said it is "being pursued with great effort."

A special NASA unit, the Space Task Group headed by Robert R. Gilruth, was given the responsibility for Project Mercury last Oct. 5, four days after the agency itself was formed. It was given not only the challenge of achieving manned orbit in the shortest possible time, but almost unlimited resources.

The technical policy adopted by the task group is to use existing technology and proved methods throughout the Mercury program to save time and money. Although this eliminated the need for new research, it has not been possible to use off-the-shelf equipment and systems in the Mercury capsule. New life support and control systems, for example, will be designed along the lines of systems proven by service in aircraft and missiles, but they still will require exhaustive development testing.

It has been possible, however, to use existing boosters throughout the program—the Army-Chrysler Redstone and Jupiter boosters and the Army-Thiokol Sergeant rockets will be employed during the sub-orbital manned and unmanned tests of the capsule and the USAF-Convair Atlas finally will propel a capsule into orbit.

Official predictions of the total cost of the program run around $200 million. NASA will not discuss the Mercury timetable or the date on which it hopes to achieve the first manned orbit because there is no way to predict how long some required test programs will last.

Unofficial estimates place the first manned orbit about two years in the future, but there are a number of reasons for believing that this may be a conservative outlook.

A definite spirit has developed among project personnel. This might be expected from a group that has been given a clear-cut, intriguing and demanding objective and the means needed to accomplish it. Mercury has the added incentive of being involved in a race against more than its own schedule. There is great hope among the task group that they will be the first to orbit a man, even though Soviet Russia enjoys a significant lead in the all-important propulsion department.

Although project leaders will not reveal their timetable, they say that the program is on schedule and there have been no slippages to date. A strenuous work pattern has evolved with virtually all of the project's technical personnel voluntarily working nights and weekends.

Mercury's record of accomplishment to date is impressive. Specifications for the capsule were established and mailed to prospective bidders 18 days after the Space Task Group was formed. This rapid handling of a difficult preliminary design job was made possible by a broad background of capsule studies conducted previously—most of them after the first Sputnik launching—by the Air Force, its contractors, and NASA's predecessor, the National Advisory Committee for Aeronautics.

Still, the task group did not spend

FIRST U. S. space pilots examine model of Mercury capsule and Atlas that will boost it into orbit. All are test pilots with 1,500 hr. in jets and equivalent of engineering or science degrees. They are now in intensive training. Seated from left are USAF Capt. Virgil I. Grissom, Navy Lt. Malcolm S. Carpenter, USAF Capt. Donald K. Slayton, USAF Capt. Leroy G. Cooper, Jr. Standing from left, Navy Lt. Cdr. Alan B. Shepard, Jr., Navy Lt. Cdr. Walter M. Schirra, Jr., Marine Lt. Col. John H. Glenn, Jr.

Priority Task

additional time deciding which of many possible configurations would be absolutely the most efficient. A NASA spokesman has described the Mercury design philosophy this way: "There are a lot of ways to skin this particular cat, but we wanted to nail down precisely what we wanted and get going."

As a result, the specifications sent to prospective bidders were much more detailed than will be usual in NASA projects. Proposals were due seven weeks after the specifications were mailed. Oral presentations were made by bidders during the Christmas holidays and NASA notified the McDonnell Aircraft Corp. on Jan. 8 that it had been chosen to build the capsule.

Technical management of sub-orbital and orbital tests is handled by a number of panels composed of representatives of contractors involved in each test. For instance, one panel including the Army Ballistic Missile Agency, McDonnell and NASA meets almost daily to make the decisions and compromises necessary to integrate the capsule and the Redstone booster into a safe system that will send the seven Mercury space pilots on 130-mi. ballistic paths.

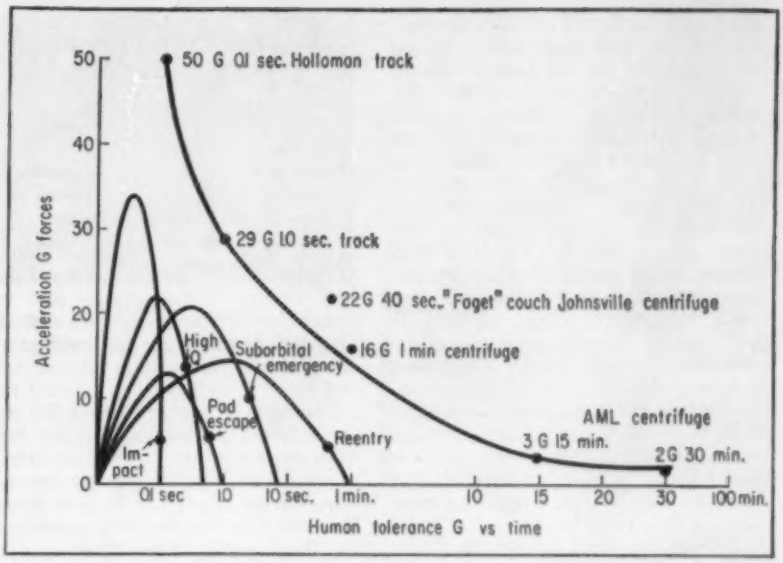
Similar panels control the preparation of the orbital vehicles. Top NASA officials retain the authority to override these panels but to date this has been done only on a few points. The almost daily panel meetings have eliminated much correspondence and produced answers to technical problems in a minimum time.

Firm Technical Foundation

All aspects of the Mercury program rest on firm technical ground. While a great deal of engineering design and environmental test work has yet to be done the programs have been outlined clearly by the wide experience gained in recent years on the major problems connected with orbital flight.

Reliability of large liquid fuel rockets essential to the program is high today and increasing steadily. NASA considers the Redstone to be highly reliable and ideal for training the pilots for ballistic flight. It also expects the Atlas to have reached a high state of reliability by the time the capsule is ready for orbit.

Tolerances of the human body to the types of stresses expected in sub-orbital and orbital flight have been well established by medical research except for man's reaction to protracted weightlessness. This is not expected to be a serious stress on the basis of present studies and experiments in short duration flight. Radiation, meteorite incidence and other possible hazards in the low-altitude Mercury orbit are not expected to offer a serious problem, based on satellite and sounding rocket data.



DYNAMIC forces to which Mercury pilots will be subjected have been explored thoroughly in laboratories. Pilots also will ride capsule in sub-orbital flights before orbiting.

In areas where there is still some doubt about the basic technical approach involved, NASA has back-up programs.

The heat shield required for the capsule to re-enter the atmosphere is being purchased in both ablation and heat-sink forms. While a great deal of nose cone investigation for the ballistic missile program is applicable to the capsule, no re-entry tests ever have been made from an orbit. Orbital re-entry occurs at speeds only slightly higher than intercontinental missile speeds but the energy that must be dissipated as heat or drag is considerably higher and the re-entry paths are different.

A final choice between the ablation and heat-sink shields will not be made until after unmanned re-entry tests have been made from orbits.

The Mercury capsule is a less complicated vehicle to develop than a high-performance aircraft and its design and test program are expected to move correspondingly faster. Some recent aircraft development programs have stretched through seven or eight years, although this lead time in some cases has been abnormally long due to financial and technical indecision.

Another yardstick is the fact that some satellite instrumentation payloads have taken two years for their design and environmental test phases. These projects did not have the maximum backing that should shorten the Mercury cycle.

Manual control of the capsule is expected to be less complicated than piloting a high speed aircraft. All of the men selected to ride in the capsule are competent test pilots and the duties they are expected to perform are minor compared to those they are accustomed to handling in the testing of supersonic aircraft. The capsule auxiliary systems and emergency procedures that they must understand are dwarfed by the number they must know intimately in a modern aircraft. Aircraft flight handling characteristics and pecularities through several speed ranges also are infinite compared to those of the ballistic capsule.

Regardless of the technical complexity of the program or of the steps taken by NASA to ensure the earliest possible manned orbit, the human reaction to

Mercury Biomedical Program Gravity Forces

Phase	G-maximum predicted	G-tolerances	Test Equipment
Normal launch	9	23	Human centrifuge
Pad escape	17	29	Hollomon track
High "Q" escape	~5	29	Hollomon track
Emergency	18	25	Johnsville centrifuge
Normal re-entry	9	16	Centrifuge
Landing impact	18-22	80	Hollomon track

the unusual nature of the Mercury project will play a major part in determining the first flight date for two reasons.

First, unless Russia wins this particular race, there is no way to minimize the fact that this will be the first time a man has ridden a missile into space in an attempt to achieve an orbit. There is no way to minimize the courage that this will require of the first space pilots. This knowledge is paramount in the minds of the managers, designers, and craftsmen connected with the project. Understandably, it will lead to unusual caution and deliberateness even though all project personnel including the pilots are convinced that this undertaking is no riskier than an experimental aircraft flight program. It makes little difference now that human travel in large rockets and in space may become almost commonplace within 10 years.

Second, the world is watching closely as Project Mercury is developed openly before it. Along with the sense of adventure and wonder that has been created, there is the added interest of watching a race between the two strongest nations on earth.

This prestige and propaganda aspect of the man-in-space program has assumed major proportions, and the highest levels of government will participate in deciding when an attempt will be made to send a U.S. pilot into space.

The pilot in the Mercury capsule will be situated in a double-walled pressure vessel made of titanium which will be enclosed in a heat protection covering. The larger end of this covering will re-enter the atmosphere first and absorb the greatest amount of heat. Both the ablation and heat-sink types of forward shield will be nearly flat and their outer shapes will be identical so that they will not change the capsule's aerodynamic stability characteristics. The rear part of the heat protection covering will be made on a very thin, high-nickel alloy that will dissipate heat energy by radiation.

Insulating material will be placed in the space between the heat shield and the pressure vessel to reduce the temperatures in the pilot's area and to serve as acoustical dampening material. High sound levels will be experienced during the take-off boost by the Atlas and during the re-entry.

The capsule life support system is designed around a maximum mission of 24 hr. A 100% factor of safety has been employed so that the system will keep the pilot alive for 48 hr. in an emergency. If the pressurization and air-conditioning system failed or the pressure vessel began to leak, the pilot would have full protection from his pressure suit for 120 min. Since the orbital period will only be 90 min. it is anticipated that the flight could be

Space Flight Milestones
Short range flights—X-15.
Orbital flights—simplest vehicle.
Orbital flights—advanced concepts.
Orbital flight—several men, several days.
Permanent manned orbital space laboratory.
Manned flight to vicinity of the moon.
Manned landing on moon and return.

aborted well before this period elapsed. The pilot actuates his suit merely by dropping the visor on his pressure helmet.

The pilot is positioned to withstand accelerations and decelerations by being strapped firmly into a contour fitting couch. The accelerative loading always will be taken from back to front. He will face forward during take-off and the capsule will be rotated as soon as the boost phase is over so that he will ride backward and re-enter in that position, no matter when re-entry is initiated. Highest "g" forces the pilot is expected to experience will be 16 to 22 g at landing impact but he could tolerate 50 g for this very short period. Maximum longer term accelerations would occur during an abort when he would receive a maximum of 18 g depending upon what portion of the booster flight it was initiated in. The pilot's tolerance to this condition has been established at 25 g.

The radiation dose that the pilot would receive during his flight will be well within the Atomic Energy Commission tolerances. The heat shield and pressure chamber stop much of the radiation.

Escape System

An escape system has been provided so that the capsule may be separated from its Atlas booster. This consists of three solid propellant rockets mounted on a tripod frame above the capsule. On a signal either from the pilot or the ground these rockets will take the capsule 250 ft. away from the booster during the first second after they are fired. The capsule parachutes would be released as these rockets burned out and just after the capsule passed its highest altitude. The rockets are adjusted so that they take the capsule a considerable distance to the side of the booster.

A number of temperature, pressure and vibration readings will be taken on various sections of the Atlas booster and its three engines. This data will be monitored closely during the boost phase of the flight and if it shows that trouble is developing in the booster the abort system will be actuated. The firing experience necessary to interpret this data properly will be supplied by Convair.

During normal launchings, the escape system will be jettisoned as soon as the capsule is separated from the booster. At that point the capsule will be pitched forward 180 deg. and rolled 180 deg. so that the pilot will be riding upright and backwards. The only way that the flight may then be terminated quickly is to fire the retrorockets located on the heat shield. When these are fired the capsule speed will be slowed 350 mph. and a slow descent will begin. The retrorockets are detached and at 60,000 ft. a small parachute is released and used during the descent to 10,000 ft. There the main parachute is deployed to lower the capsule to the ground.

The first manned Mercury orbit as now planned will consist of three circuits. The launching will take place from Cape Canaveral just a little bit north of east. On the third and final orbit the capsule will pass near Hawaii and the retrorocket will be fired about 400 mi. off the Pacific coast of the U.S. in order to land it near its launching point.

The capsule's attitude control system will consist of small hydrogen peroxide rockets to control roll, pitch and yaw. An automatic pilot will operate this system through signals it receives from an infrared horizon scanning unit that will operate equally well on the dark or bright side of the earth. The pilot also will have a manual control by which he can override the autopilot if it malfunctions.

The pilots will become proficient in the operation of the capsule and its manual control by spending hundreds of hours in simulators.

The five simulators in the present program are:

- **A fixed analog** simulator at Langley Research Center, which will reproduce the stick forces that the pilot would feel. This resembles the simulator used to train pilots to fly the "X" series of aircraft.
- **Iron cross simulator** at Langley, which will subject the pilot to the actual motions of the capsule and train him to control them.
- **Procedures trainer** at Langley, which will present all possible combinations of emergencies and give the pilot proficiency at rapidly overcoming them by actuating the proper systems.
- **Environmental simulation** by placing the capsule in the large altitude wind tunnel at the Ames Research Center. The capsule would be rigged in the tunnel to respond to the attitude control jets. Tunnel air would be evacuated so that orbital conditions would be simulated as closely as possible and the control system given an operational test. It is not certain at present whether the pilots will spend any time in the capsule while it is in the Ames tunnel.
- **Weightlessness simulation.** Pilots will

get accustomed to weightlessness by flying in the Air Force C-131 which is used at Wright Air Development Center to achieve zero g for about 15 sec. at a time. The pilots will learn to perform many of the necessary capsule operations during these conditions.

The aim of this simulator training is to give the pilots the ability to control the capsule during the whole flight if necessary. At the moment, plans are to let the automatic pilot control the capsule continuously with the pilot monitoring it. The automatic system would also control the re-entry angle, which is very critical. There is some feeling, however, that the pilots may prefer to handle this task themselves. The first manned re-entry probably will be made with the pilot closely monitoring the automatic system. The ability of the automatic pilot to control the whole flight will be proved first in unmanned orbits.

Navigation and Tracking

The Mercury orbit will be determined from tracking information gathered by a number of ground stations. Atlantic Missile Range radars will give the early orbit, which is very critical. If trouble develops and the flight must be aborted, the tracking computer program must instantaneously show the orbital trajectory and the spot at which the capsule will land. In this way it will be possible, sometimes by waiting several seconds to initiate the abort, to bring the capsule down in the most favorable location. This data will be supplied to the pilot by radio as well as to ground controllers.

A world-wide system of tracking and control stations will be established to monitor the Mercury orbits. They are planned so that the capsule will be in contact with each one for about 5 min. and never out of contact with a station for more than 10 min.

To guard against complete communication failure, the pilot also will have the means to determine his orbit, his position and his landing spot if he used the abort system. The accuracy of his calculations will be much lower than those of the ground tracking and computer system. His primary navigation instrument will be a periscope device. It will be equipped with a swiveling head and a number of graduation lines and circles. The pilot will be able, with proper zeroing and sightings with this instrument, to determine altitude and his approximate position. Using a stop watch and making a number of these observations, he will be able to determine his apogee and perigee altitude and location.

A small slide rule type of computer will then enable him to determine his orbit and his landing position at any time he chooses to abort.

FULL-SCALE model of Mercury capsule is prepared for test launching at Pilotless Aircraft Research Station, Wallops Island, Va. Exhaustive capsule testing has been done by nearby Langley Research Center. Models fired over ocean are recovered by helicopter.

BOILERPLATE models are fired to 2,250 ft. by escape pylon, powered by modified Recruit rocket motors, to test capsule's stability with escape system. Pylon falls away and parachute deploys, lowering capsule to water. Boats recover parachutes for later tests.

MECHANIC in aluminized suit adjusts model of rocket-boosted glider in Langley Research Center's supersonic wind tunnel. Air is heated to 400F by moving it at 3,500 mph. Suit allows mechanic to inspect model without waiting for tunnel to cool.

Planetary Flight Is Major NASA Goal

A major goal of the national space program is to land men on the planets of the solar system and return them to earth. Every space project on which the National Aeronautics and Space Administration is now embarking is intended to supply some information, some experience, some capability that is needed if this primary objective is to be reached in some future decade.

Space medicine studies, the large booster projects, the space sounding and radiation investigations—all point toward the creation of vehicles that can carry man into space for a year or more at a time.

These vehicles will push present technology to its limits principally because they must be propelled by the most powerful engines yet devised and because they must carry "perfect" machinery that can operate without failure or maintenance for many months. Deciding when manned interplanetary vehicles and their boosters will no longer be the dominant goal of the space program is a moot question today and probably depends on basic physical discoveries that will offer new means of propulsion.

An orderly evolution of manned U.S. space craft from the Mercury capsule to the interplanetary vehicle has been outlined by NASA. Considering only the vehicle itself and disregarding such absolutely essential elements as the boosters and communication and navigation equipment, the major development phases can be broken down as follows:

• **Mercury type drag capsules** and Dyna-Soar type lifting vehicles that will travel equally well in space or the atmosphere. These craft eventually will have several crew members but will remain aloft for limited periods because of their small size.

• **Space laboratories,** or satellites the size of a five to seven room house, which can support several crew members for virtually unlimited periods and allow continuous and detailed observations and experiments to be carried out. Laboratories of this general type probably will be invaluable for testing equipment and components for interplanetary vehicles in a true space environment. While the equipment in the satellite laboratory would have to be of high quality, it would not be subject to some of the more stringent design requirements of the interplanetary journey. This is because the laboratory would be readily accessible to resupply, maintenance and rescue vehicles from the earth.

• **Lunar vehicles** will in many ways bridge the gap between the satellite laboratory and the interplanetary vehicle. The lunar craft probably will push the equipment reliability requirement a little farther along and it will have to have the ability to land on and then make an unattended takeoff from a large body in space.

• **Interplanetary vehicles** will require some of the most advanced and sophisticated equipment that man can visualize today. Along with maintenance-free machinery, this vehicle will need an elaborate, foolproof system to solve

the food and human waste problem and a great deal of psychological support for its crew if the solar system is to be explored at the relatively low speeds which seem possible now. Trips to the nearest planets, which are now being studied, will last a total of more than two years.

A good indication of where the manned space vehicle program stands at present is the amount of money going into each phase. The Mercury program as described in the previous article is in the hardware stage and will have received about $130 million by the end of Fiscal 1960. The entire program now is expected to cost about $200 million before it is completed. Thousands of men already are employed directly on the Mercury project.

The Dyna-Soar program is in its very early stages and is now being managed jointly by the Air Force and NASA as a research aircraft to follow the X-15. A few million dollars have been spent to date on Dyna-Soar studies and a few hundred men in industry and the government are now directly involved on the project. The aircraft has not reached the detail design or construction phase and probably will not fly for three or four years. Orbital flight in such winged craft is without doubt many years away.

The Dyna-Soar is a more difficult vehicle to design than the Mercury capsule primarily because it slows down more gradually in the atmosphere and is exposed to high aerodynamic heating for a longer period. Its great attraction is that it will be much more controllable in the atmosphere than the pure drag capsule. This quality would ease the guidance problem for space vehicles entering planetary atmospheres, as will be discussed later. It also would provide a more useful and versatile vehicle for servicing satellites and for any use near the earth that involves travel in both the atmosphere and in space.

First Dyna-Soar vehicles will probably be confined to a very narrow flight corridor of permissible speed and altitude combinations. Aerodynamicists expect that the challenge of widening this corridor and increasing the usefulness and versatility of winged vehicles will continue for many years. Widening this flight corridor involves increasing the maximum skin temperatures that the aircraft can withstand so it can fly faster at the low altitudes; and improving its aerodynamic lifting efficiency so it can fly higher at low speeds.

A vital part of the research that will help widen this flight corridor is related to developing materials that will retain good structural qualities at temperatures approaching 5000F. Every gain that is made in this basic research area will provide an improvement in propulsion systems as well as structures, so that the job of vehicle design would be simplified from two directions.

The space laboratory program is in the study phase and $2 million is programed by NASA during Fiscal 1960 for theoretical investigations of the problems that will be involved in operating manned and unmanned laboratories or stations in orbits near the earth.

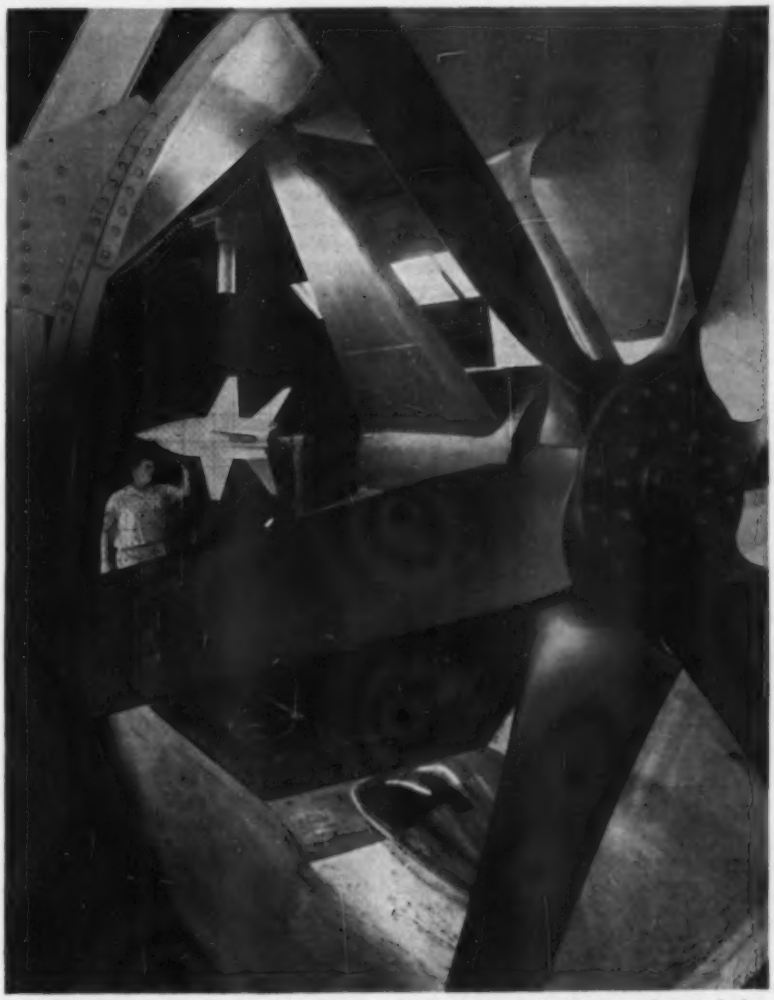
Booster Developments

D. D. Wyatt, technical assistant to NASA's Director of Space Flight Development, recently told Congress that this laboratory program—just as all other NASA plans—will have to be keyed to booster development. The management objective is to have laboratories of increasing weight and complexity ready for use as more powerful boosters become available.

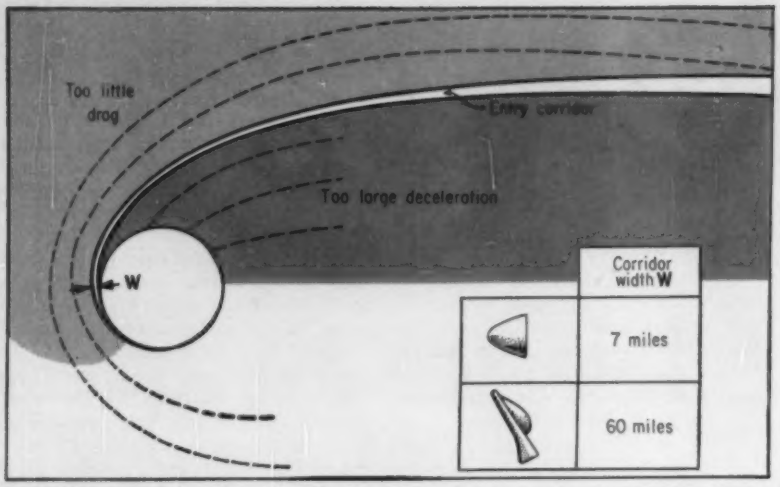
General purpose of the orbiting laboratories is to expose men and large equipment systems to actual space conditions for very long periods. They also will be invaluable for performing more elaborate measurements and observations of space conditions and the universe than will be possible with unmanned satellites.

Wyatt said that Vega and possibly Centaur would be the first boosters capable of putting up "a large enough vehicle to contain the life-support systems and all of the equipment that we would desire to sustain a man (in orbit) for a period of from days to weeks and perhaps on into months." He listed a specific objective in this area as putting "two or more men for as much as three months for a long term study of their actions and psychological and physiological reactions to this space environment for this long period."

In the equipment testing area, certain smaller systems might be tested before Centaur or Vega become available. This would be done by placing them in orbit in capsules equipped with the necessary power supply to operate the



EARLY X-15 shape in Langley free flight tunnel tests low-speed stability and control characteristics of use of differential control of horizontal tail to produce roll.



BRAKING on entry into planetary atmospheres is limited to corridors by heat, deceleration considerations. Single-pass entries are preferred due to possible radiation hazards.

system. Data on their functioning could be telemetered to the ground and the capsule recovered after several months in space so that a close inspection of the test specimen could be made.

Still more elaborate laboratories are seen as a requirement of the more distant future. "We feel we need to go beyond this temporary sort of a space laboratory, and will eventually want a permanent laboratory to which we can take men up and bring them back," Wyatt said. This laboratory would be the size of a small house and have a dozen or more men in its crew.

The first vehicle capable of putting up such a unit in one piece would be the Nova with 6 million lb. of thrust in its first stage. Nova is expected to be ready sometime after 1965. It is possible, however, depending on the availability of this booster, that the permanent laboratory would be put up in sections by the Centaur or Vega and assembled in orbit.

Discussions of the great commercial and scientific benefits of such a gravity-free laboratory above the atmosphere have indicated that its operation probably would be divided into four principal areas. The first would deal with observing the earth, its atmosphere and space around the earth. The second would involve astronomical and cosmological observations. The third would be basic research in physics, medicine, and other sciences, which would determine among many other objectives the detailed effect of the space environment on materials and living tissue. The fourth would involve testing of equipment for future space vehicles.

The biomedical questions about man's adaptability in space should have been resolved in most respects by the time such a laboratory was launched, and the crew of this station would be operating personnel concerned primarily with performing their assigned technical tasks.

Present NASA thinking is that permanent laboratories would be supplied frequently from the ground. They probably would have equipment to replenish the air supply rather than bringing new oxygen aboard at regular intervals. Food resupply and waste disposal might have to be handled by maintenance vehicles from the earth, at least in the early stages of the laboratory's operation, since a man eats his own weight in food every 20 days and consumes more than a ton of food in less than a year.

Ecological System

One of the more important long-range goals of the biomedical program is to develop a closed ecological system that will provide food and water from human waste, with the only input being electrical power. Douglas L. Worf, chief of NASA's Biomedical and Life Support Systems, predicts that a prototype recycling system based on the use of algae might be ready for testing in about five years. Not the least of the problems involved in regenerating waste is the esthetic one.

While orbiting laboratories are still very much in the conceptual stage, the need for them has been made clear by Wyatt and other NASA officials.

"The information that we learn from experiments conducted in laboratories of this sort will be vital to the successful accomplishment of really ambitious missions such as manned flight to the moon," Wyatt told Congress.

An indication of the effort presently being applied to lunar exploration is the appropriation of $7.15 million that NASA has budgeted for this purpose in Fiscal 1960, exclusive of vehicle development. The exploration of the moon will fall into four separate phases, which will be timed to the successful development of certain boosters. These phases are:

• **Orbiting the moon,** impact, and hard landings. It should be possible to accomplish these maneuvers with certainty once the Thor-Delta booster becomes available early in 1960. This vehicle will have a guidance system located in the second stage that will function throughout the burning of the first two stages. This provides a significant improvement in accuracy over the first space probe vehicles used by the U. S.

J. Allen Crocker, chief of NASA's guidance and control program, has indicated that there is a feeling of urgency about getting instruments onto the moon's surface and that NASA is examining, "instruments which can be designed and built to withstand impacts of the velocities of the order of 7,000 to 9,000 fps. and continue to operate after these impacts."

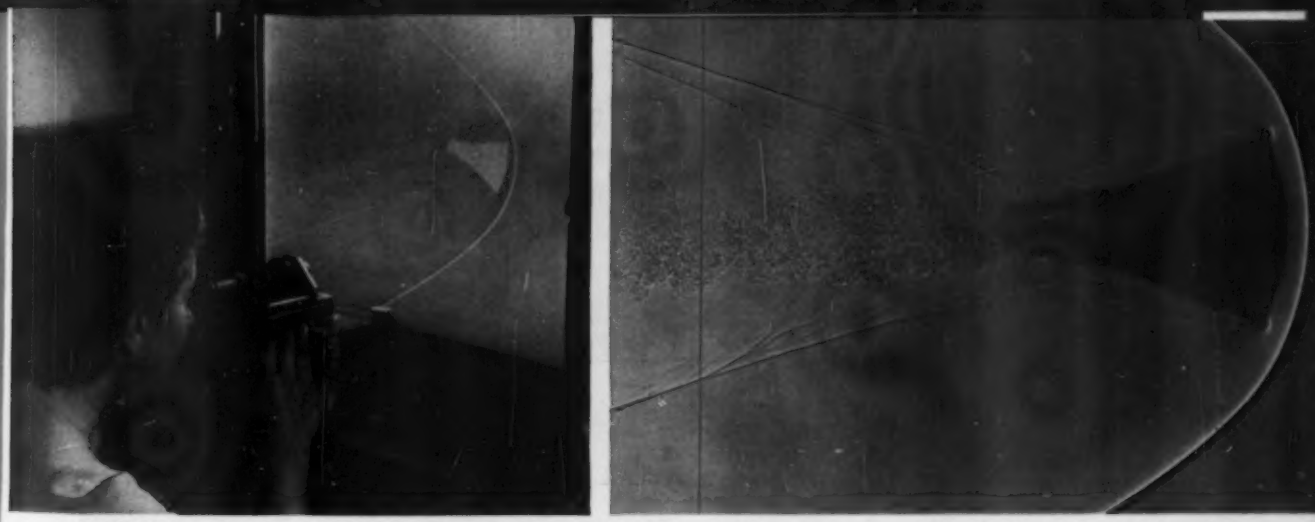
Two types of shock absorbing vehicle to land these rugged instruments are being considered. One is a spherical container with the instruments in the center, surrounded by a shock absorbing material. The outer surface of this package would be designed to deform a great deal upon impact. Another potential design would employ a long tapering spike that would absorb energy as it penetrated the moon's surface for a considerable distance. Shock loading of the instruments would be reduced further by constructing the upper part of the spike like an accordion so it would absorb more energy as it collapsed.

An alternate approach to the landing problem is to take about half the Thor-Delta impacting payload and use it for a small retrorocket, which would slow the package just before it hit the moon. This less severe impact would allow the instruments to be lighter and less rugged. The landing still would be considered hard, however, and the choice between full-impact and hard-landing design has not yet been made.

Unless this type of instrument package delivery can be accomplished within about 18 months, the project probably will be abandoned because larger boosters—able to carry enough payload to allow a soft-landing—should be available by then, Crocker said.

Orbiting the moon is considered to be an easier job than impacting with a simple vehicle, because the simple vehicle would have to enter the moon's gravitational field precisely along a radian to avoid being diverted from its proper course.

The Thor-Delta orbiting payload would be reduced to about 65 lb., with



MERCURY capsule model fired at Mach 3 by high-speed gun along instrumented range at Ames Research Center shows airflow characteristics. Apparent bulge at edge of model face is optical distortion. Serrated base is for holding model in launch gun.

35 lb. being devoted to a retrorocket. NASA hopes that such vehicles will make it possible to gather improved information on the lunar mass and to make a high-resolution lunar map.

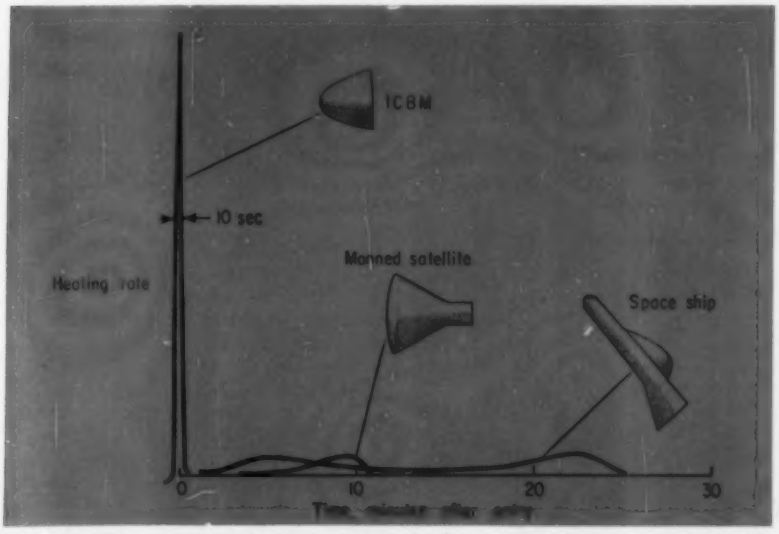
• **Soft landings.** The Vega vehicle, scheduled for first firings about mid-1960, and the Centaur, to be ready early in 1961, will be able to make soft landings on the moon with a 430-lb. and 730-lb. payloads, respectively. Purpose of the soft landing is to position scientific instruments at precise locations on the moon's surface. Soft landings have a number of requirements which call for a much more sophisticated vehicle than the Thor-Delta. These include terminal guidance located in the last stage; attitude and altitude control of the vehicle as it approaches the moon; a retrorocket to cancel virtually all of the forward velocity of the vehicle; ability to maneuver above the surface of the moon so that the letdown point can be selected, and some means of absorbing landing shock.

Both the Vega and Centaur will also be used to carry large payloads into orbit around the moon to aid in mapping and general reconnaissance. They might also be used to make hard or impact landings.

• **Soft landing and return** to earth. Saturn vehicle, with 1.5-million lb. of thrust in its first stage, will be needed to land a 200-lb. payload softly on the moon and return a part of it to earth. The payload would use its landing gear as a firing platform and leave the gear behind on the moon to lower the weight to be returned to the earth. The payload would be recovered on the earth in drag capsule fashion, using retrorockets. Saturn might possibly put a man into orbit around the moon, but this mission presently appears so marginal that it may not be attempted.

• **Manned lunar landing.** This will have to await development of either the Nova chemical rocket, weighing in the neighborhood of 5 million lb., or of nuclear rockets, which would allow a vehicle of much lower total weight to be used. NASA estimates today are that the manned landings on the moon will not occur before 1970. Prior to this, however, manned vehicles boosted by a Nova or a similar vehicle probably will have circled the moon and returned to earth.

Nova's payload capacity is not particularly high for the manned landing on the moon. The big rocket could only return a 2,100-lb. payload to earth. One method of taking this mission out of the marginal category is to cache food and fuel on the moon at the location where the Nova vehicle would land. Stocking these supply depots with soft landing vehicles prior to a manned trip is being considered by the NASA.

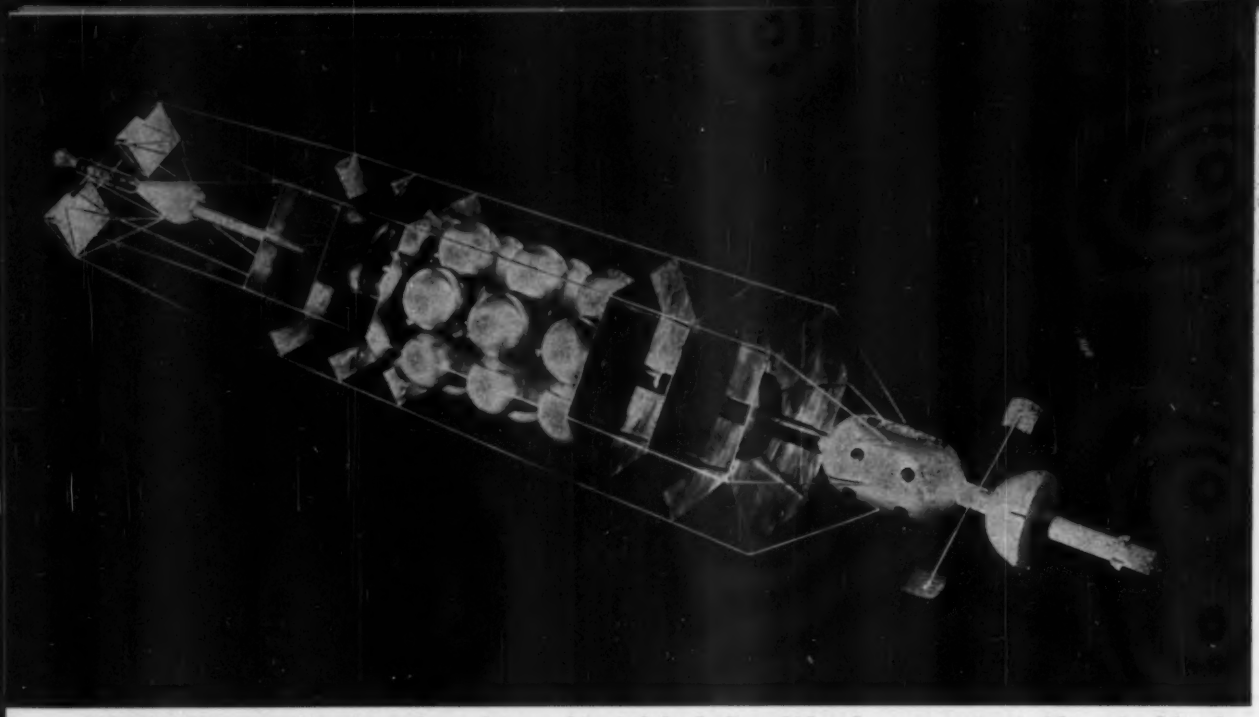


HEATING differences in drag bodies such as missile noses and Mercury capsules and lift vehicle (right) indicate that future landing vehicles will be lifting shapes. Pure drag vehicles also may be used as escape capsules for earth-orbiting spaceships.

Interplanetary Vehicles

NASA has requested $6,803,500 for deep space probe work during Fiscal 1960, not including vehicles. This money would be used to continue a program in progress during Fiscal 1959. Part of this 1959 program was to develop a vehicle which could travel along the minimum energy trajectory to the Venus orbit.

Two vehicles, one a Thor-Able and the other an Atlas-Able, are being constructed for this purpose. They were to have been preceded by a Thor-Able test of payload components, fired into an elliptical orbit. The most favorable firing period for Venus would have occurred on June 8 and the total energy required to come within the vicinity of that planet increases every day after that as Venus moves farther away from the earth. One or both of these vehicles probably could reach Venus if they are



HYPOTHETICAL space ship using nuclear rocket propulsion includes landing vehicle and crew compartment, right; engine, left; spherical tanks for liquid hydrogen propellant; shields to protect tanks from solar radiation, reactor heat.

launched any time during the 30-day period after June 8. The energy requirement goes up rapidly after the first of July, and it is probable that no U. S. rocket could reach Venus until the next minimum energy period on Jan. 13, 1961. Next Venus date would be Aug. 16, 1962. Favorable dates for Mars launchings are Oct. 1, 1960 and Nov. 16, 1962.

If the Thor-Able and Atlas-Able designated for the Venus shots are not used for this mission, they probably will be employed late in the summer in other programs. One Thor-Able still may be used to boost an instrument package into a highly elliptical earth orbit with a 200-mi. perigee and 30,000-mi. apogee. The Atlas-Able may be used to orbit a payload around the moon.

A number of studies of interplanetary vehicles have been conducted by some of NASA's best scientists. The chief purpose of most has been to determine where further research effort can be most profitably applied. These exploratory studies have investigated vehicles powered by chemical, nuclear and electric engines and they furnished the direct impetus behind much of NASA's current and planned research program. A very large percentage of the information needed to design interplanetary vehicles will not be obtained through any earth-bound research program, however, and much of the detail design data for these craft will have to come from the orbital laboratories that NASA is planning.

Rather extensive studies already have been made of the problem of entering the atmospheres of other planets after a flight from earth. Dean R. Chapman, NASA aerodynamicist, has directed most of this work.

Chapman points out that a space vehicle on any trip between earth and Mars or Venus will approach its target planet with about twice the kinetic energy of an earth satellite or an intercontinental missile. The ideal solution would be to use rocket braking alone to make a landing, but this would require a rocket system as large as the booster rockets that propelled the vehicle in the first place. The total weight of such a vehicle would be 30 to 50 times as large as those now contemplated. In view of this the research effort is being directed toward solving the entry problem by using aerodynamic drag, with rocket power during this phase limited to making small corrections in trajectory.

Radiation Hazard

Multiple-pass atmospheric braking, which looked very promising until last year, is being discarded. This is because the space vehicle would have to pass through any radiation belts several times as it grazed the edge of the atmosphere and cut its velocity very slowly. The weight of shielding required to protect occupants during these passes would be "impossible," according to the information available now, Chapman said.

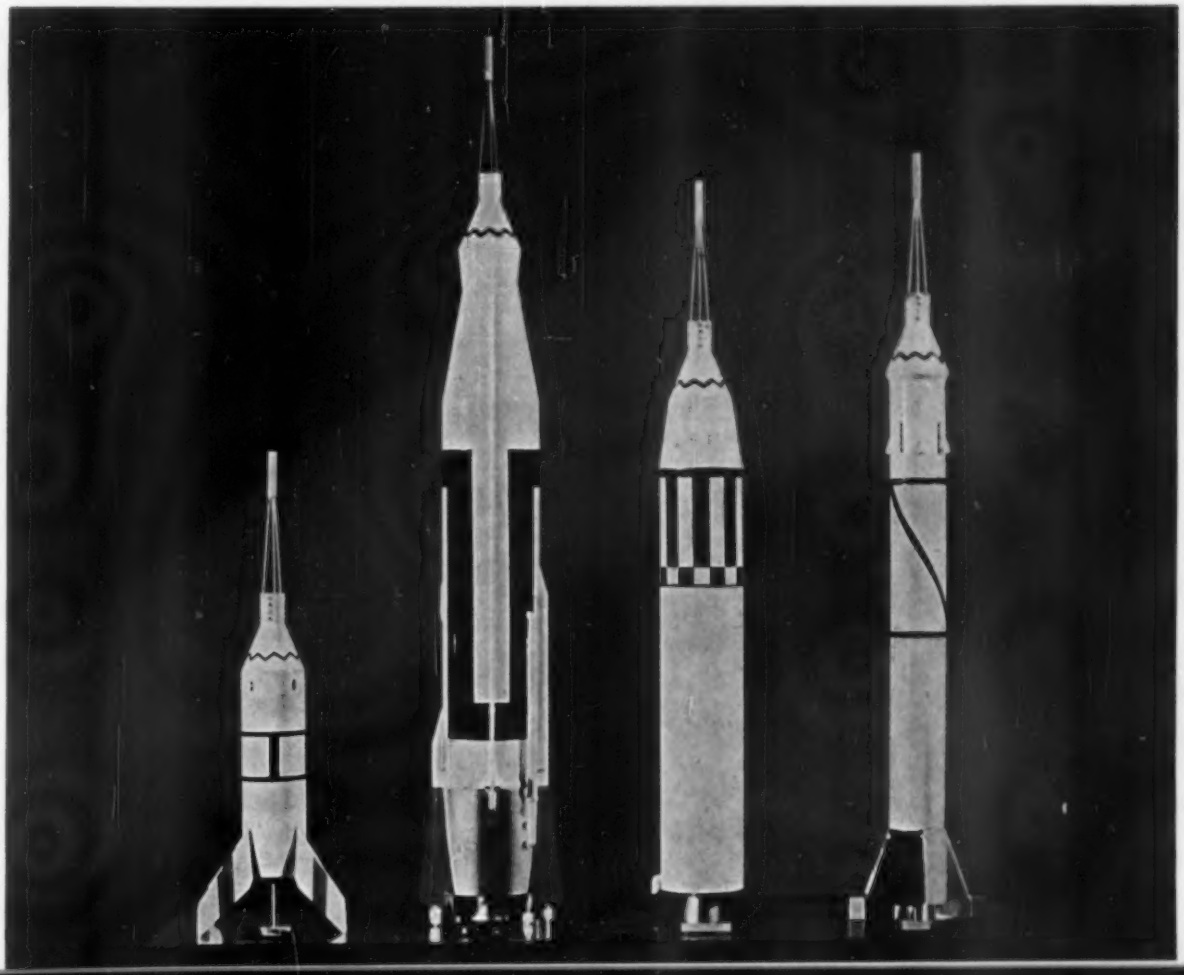
While it is not certain whether radiation fields of the same type and intensities as the earth's fields exist around Mars and Venus, a single-pass landing method is being studied seriously for the return flight to earth, and probably would also be employed for landing on the other planets.

On a single-pass landing, the vehicle must be guided down a narrow corridor if aerodynamic drag is going to cut its speed enough to land without slowing it too rapidly and producing decelerations that would kill its crew. The earth's landing corridor for a nonlifting drag vehicle of the Mercury type is only seven miles wide. If a lifting vehicle can be used, the corridor will be widened to about 60 mi. But this is still less than one per cent of the diameter of the earth, and presents a very severe guidance problem. The penalty for widening the corridor is the greater weight and complexity of the winged vehicle.

The single-pass landing corridor on Venus is about the same size as that for the earth, but the Mars corridor is much broader. Landing corridors for the other planets vary considerably. Jupiter's corridor, for instance, is much narrower than the earth's. NASA officials already are discussing unmanned probes to the vicinity of that planet. Of the three planets that will be involved in manned trips from earth to Mars or Venus and return, the earth landing problem is the most severe as far as vehicle decelerations and surface temperatures are concerned. A demonstration by an unmanned vehicle that such a one-pass landing is possible probably will precede any manned flights to the nearest planets.

MANNED flights to planets may await nuclear electric engines. This is a proposed Mars vehicle.

TEST vehicles for first manned orbital flights, from left, Little Joe, Atlas, Jupiter, Redstone.

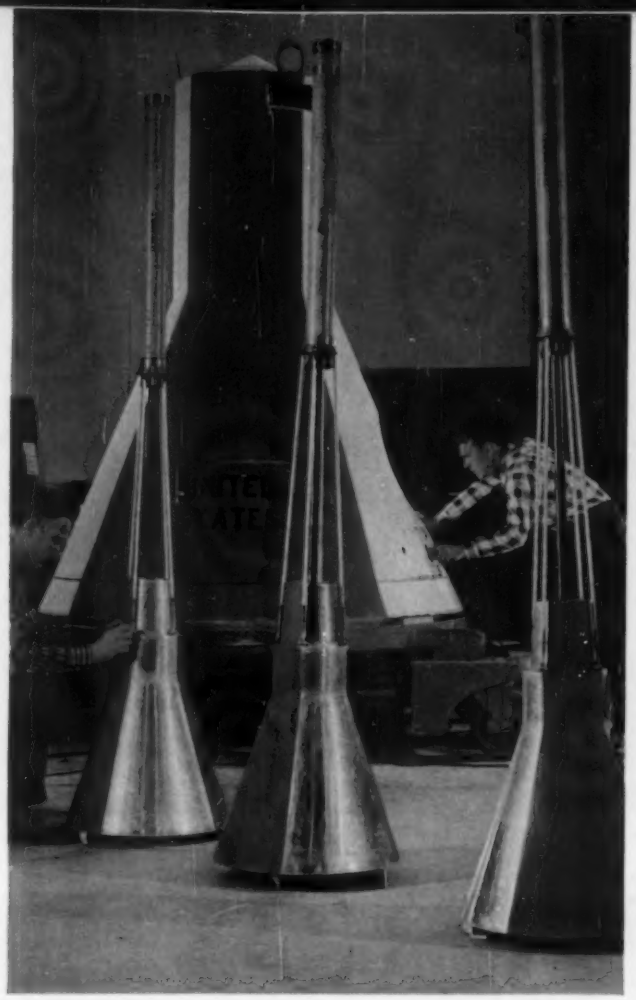


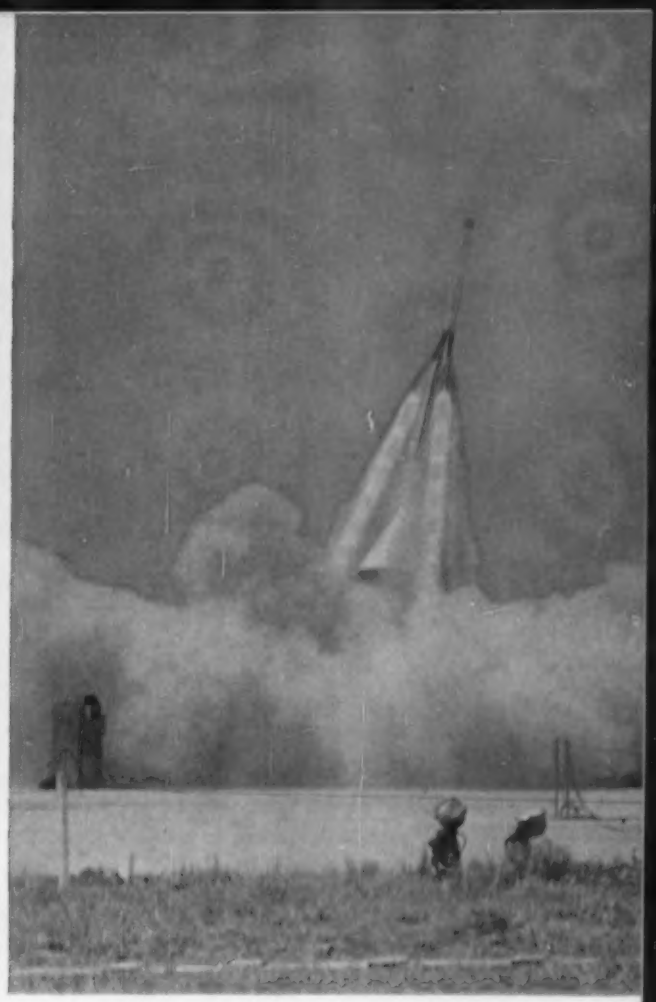
CATHODE jet is obtained in electromagnetic traveling wave plasma accelerator used in space propulsion study at Lewis.

RED-VIOLET flame indicates boiloff of lithium vapor from electrodes as accelerator starts. Researcher is Robert E. Jones.

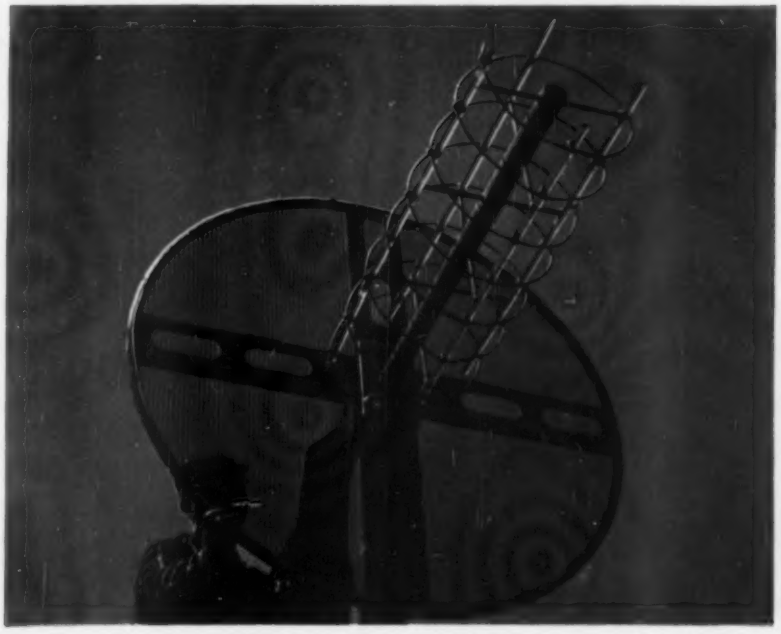
EXTERNAL fuel burning studies at Lewis. Possible future uses are for boost-glide control, propulsion system for cruise at Mach 5-10.

ION accelerator at Ames studies surface pitting effect of ionized gases on spacecraft at speeds of 15,000 mph.

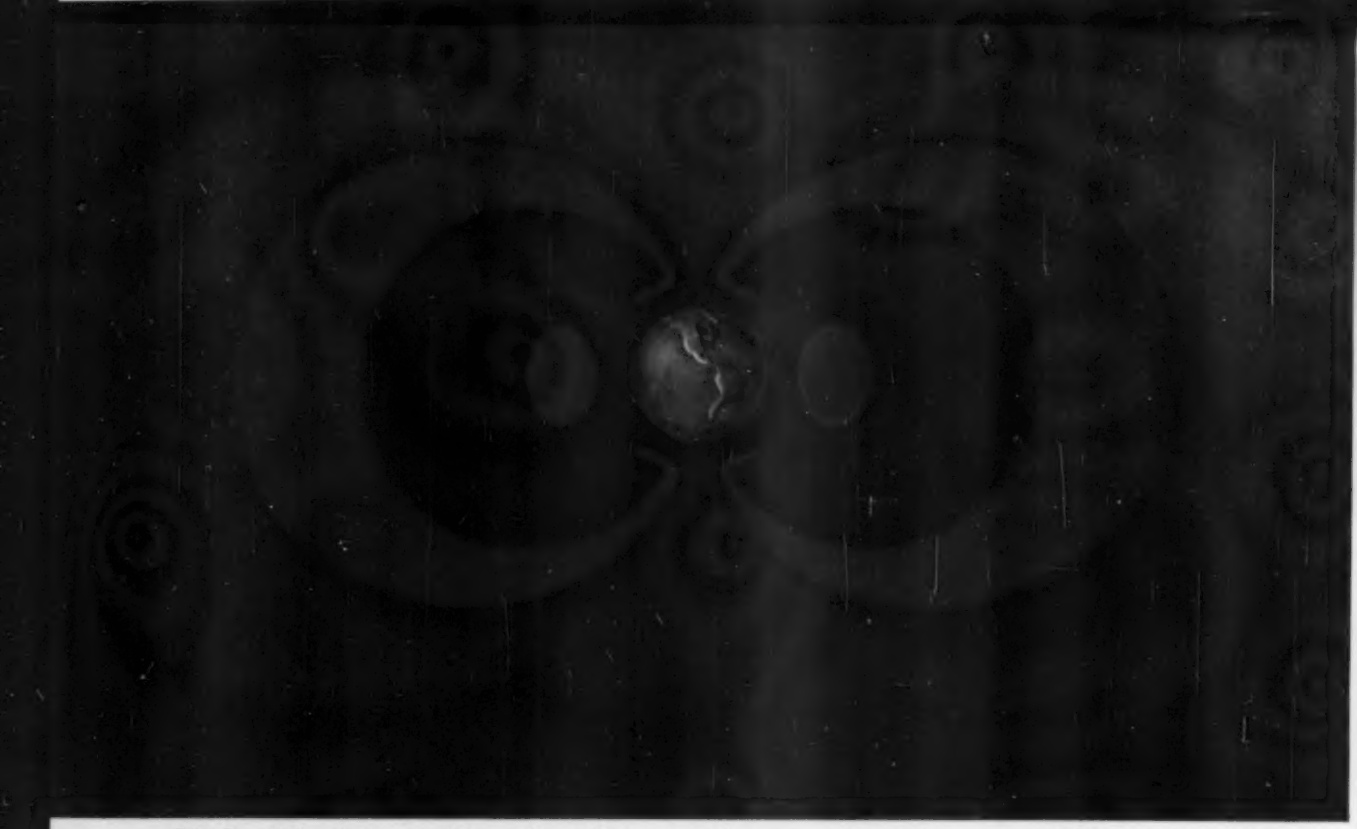




ONE-THIRD scale models of Mercury capsule, left, at Langley, are fired to 1,000 ft. to test effect of escape nozzle cant on capsule's stability. Right, full-scale boiler-plate model is fired to 2,250 ft. at Wallops Island in escape system test.

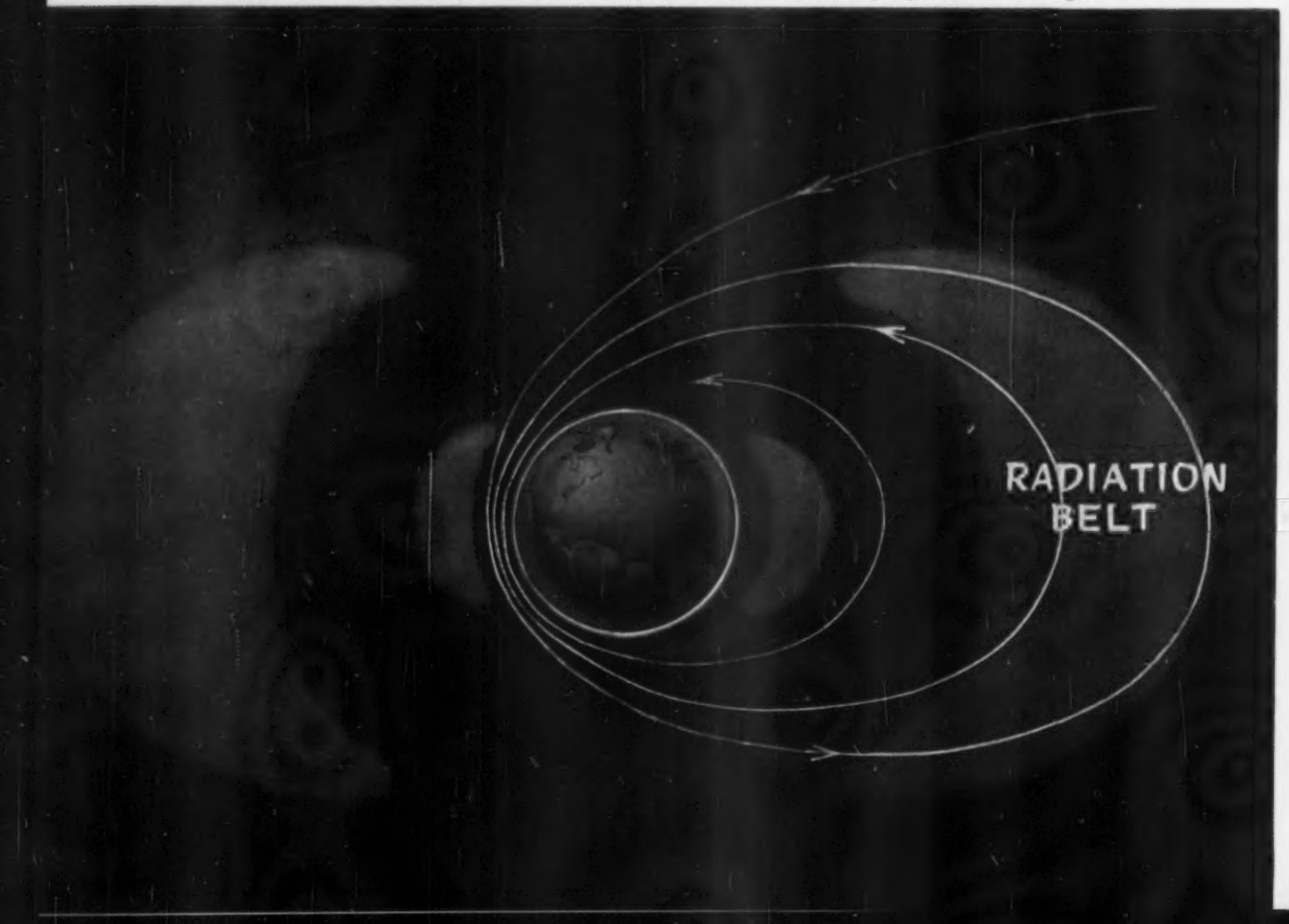


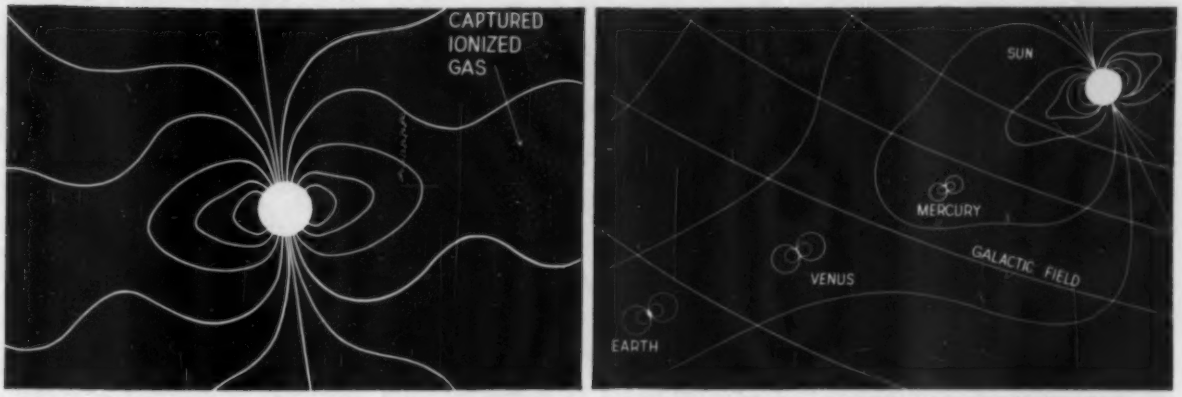
HELICAL telemetry antennas receive temperature, pressure, acceleration data from dynamic models of spacecraft fired by rocket over Atlantic from Pilotless Aircraft Research Station at Wallops Island, Va. Station is now being expanded.



GREAT radiation belts, found by early satellites, raise still unanswered questions on manned flight.

BELTS around earth and possibly other planets may eliminate low-heat multiple passes for landings.





UNKNOWNS include theory that ionized gases from sun compress earth's magnetic field; theory that planets, sun and galaxy have magnetic fields. Estimates on intensity of possible intergalactic field vary by more than one million.

Sciences Program to Probe Universe

The bold space sciences program of the National Aeronautics and Space Administration will probe from the shores of the earth's own atmosphere through the solar system and into the far reaches of the universe.

The NASA program could have a far greater impact on present frontiers of knowledge than the great age of exploration that opened the Western Hemisphere in the 15th century.

To the space scientist, powerful rockets and exotic fuels are not an end in themselves–only a means of carrying scientific instruments out to where measurements can be made that will reveal what heretofore has been limited to conjecture. In answering questions that have long intrigued scientists, NASA's program promises to raise many new questions, but this is the purpose of scientific investigation.

Experiments Planned

Here are a few examples of space science experiments currently programed or planned:

- **Interplanetary probes,** to measure the pressure, density, temperature and composition of the atmospheres of Venus and Mars.
- **Ionosphere studies** of the regions surrounding earth and other planets, and their effects on radio communications.
- **Origin of energetic particles** such as cosmic rays and Van Allen radiation belts, and their reactions with space vehicles, the earth and other atmospheres.
- **Mapping of the solar system's** magnetic field and study of anomalies in the earth's magnetic field.
- **Space astronomy,** using a telescope mounted on an attitude-stabilized satellite, to observe radiation from celestial bodies that now is absorbed and/or filtered by the earth's atmosphere.

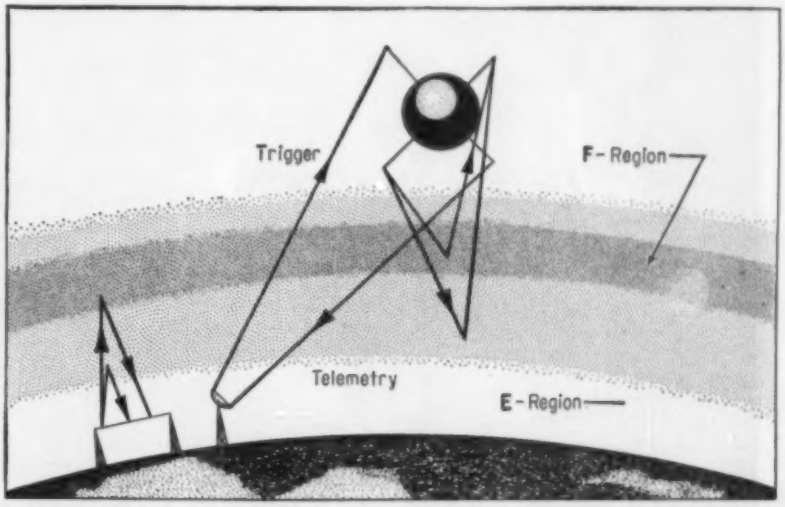
Although man lives in a world of physical phenomena that are governed by "fields," such as gravity and magnetic fields, scientists have very little realization of the true nature of a field, according to Dr. Robert F. Fellows, head of NASA's chemical aeronomy program. A field usually is described by the effect it produces, such as the pull of gravity or the use of a magnetic field to generate an electric current.

Aside from fundamental scientific curiosity about the nature of fields, they are important for practical reasons, Fellows points out. For example, fields determine the motion of all free particles, from the tiniest electron to distant galaxies.

One of the most familiar is the earth's magnetic field, yet it poses many unanswered questions. Its strength, uniformity and orientation shifts slowly over a period of years, in what is known as secular variation. More recently it has been discovered that it has a 24-hr. (diurnal) cycle of very small magnitude.

"There also are brief sinusoidal variations with periods of a second to a few minutes, which may persist for up to half a day. The magnitude and frequency of occurrence of these variations depends upon geomagnetic latitude. Greatest magnitude is found in the auroral zones. Finally, there are magnetic storms that produce large, sudden variations over portions or all of the earth.

One theory is that some of these variations in the earth field result from electric currents flowing in and above the ionosphere. The currents are at-



CANADA will supply satellite, U. S. the booster, for ionospheric "topside" sounder that will provide simultaneous study of ionosphere's nature from above and below.

Energetic Particles—18-Month Program

Purpose	Launchings
Cosmic ray intensity in interplanetary space	2 probes, 1 satellite
Cosmic ray fluctuations	1 satellite
Cosmic ray energy and charge spectrum	1 probe, 2 rockets
Radiation belt composition and extent	2 satellites, 4 rockets
Auroral particles	12 small rockets

Ionospheres—Two-Year Program

Purpose	Launchings
Ionospheric structure, very low frequency propagation, ionic interaction with rockets	7 sounding rockets
Ionospheric structure, propagation, ionic interaction with satellites	5 earth satellites
Ionospheric structure to many earth radii	1 space probe

tributed to the dynamo action of tides and winds in the ionized gas and to the influx of particles from the sun.

Another recent theory, not yet confirmed, suggests that clouds of ionized gas from the sun generate a magnetic field which interacts with and compresses the earth's magnetic field.

Under other conditions, where the type of particle and energy level is different, the particles may become trapped in the earth's field, causing a weakening of the field. As particles oscillate back and forth along the earth's lines of magnetic force, they may produce short-term pulsations in magnetic field strength as measured at the earth's surface.

It is known that the sun has a magnetic field which varies in intensity with the appearance of sun spots and bursts of solar energy. Some scientists speculate that Venus, Mercury and possibly other planets have such magnetic fields, but there is no data to support this belief. Scientists also suspect that there may be an intergalactic field, but again there is no confirmation.

Present NASA plans call for a lunar space probe using a rubidium vapor magnetometer developed by Varian Associates to measure electric currents and earth's field at great distances, as well as the interplanetary and lunar magnetic fields. A number of small sounding rockets will be outfitted with proton magnetometers to study ionospheric currents. Two satellite experiments are planned to obtain data that may show the relationship between magnetic storm bursts and changes in the field on the earth's surface.

Beyond this short-range program, NASA hopes to measure magnetic fields of Mars and Venus, initially through close approach and eventually from instrument package landings.

Einstein's general theory of relativity suggests that gravitational fields slow down physical processes, Fellows points out. This means that if one of two identical clocks is located in the gravitational field of the earth, and the other is placed in a satellite where it is exposed to a much weaker earth gravity field, the satellite-borne clock should run slightly faster, i.e. gain time.

NASA plans an experiment using extremely precise atomic clocks to test the validity of this aspect of the relativity theory, which forms a cornerstone of modern physics and astronomy. Signal from the satellite atomic clock will be telemetered down to earth for comparison with the earth clock.

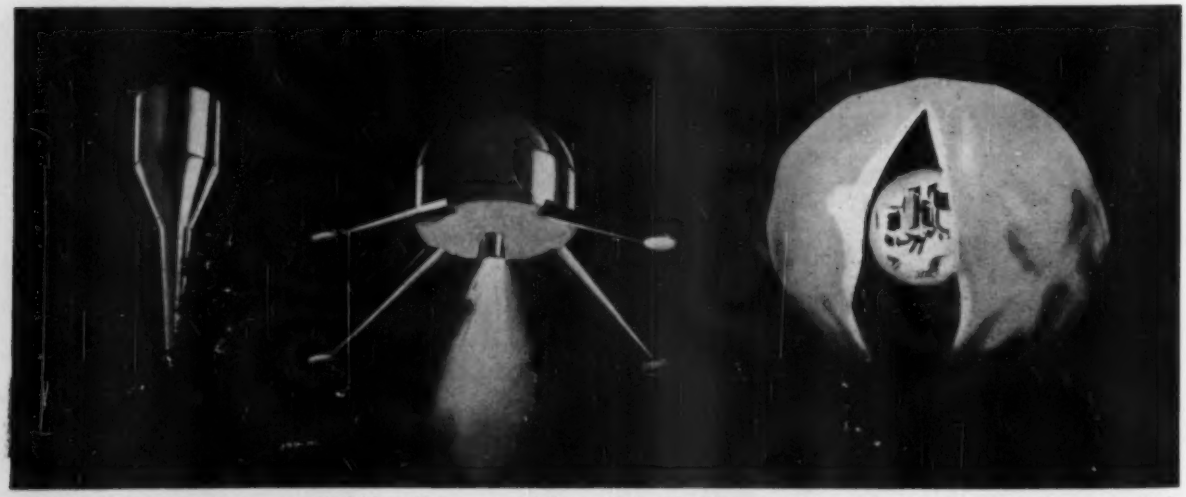
Fellows warns, however, that the experiment will require a great deal of precision and control because of the extremely small effect to be observed. If the satellite orbits too close to the earth, the result may be an opposite effect that would cancel out the slight time shift that must be observed. An orbital altitude of 4,000 to 5,000 mi. should prove adequate, Fellows believes.

Origin of the Universe

By examining radiation and matter from space before it is absorbed, filtered and/or contaminated by earth and its atmosphere, NASA scientists hope to shed light on the question of how the universe began—whether it is continuously expanding from a fixed nucleus of matter or whether matter is in a continuous process of creation—according to Dr. A. O'Keefe, assistant chief of NASA's Theoretical Division.

Although meteorites have been found on earth, scientists are not certain they are the same as the meteors that light the summer sky. Meteorites found on earth are solid and hard whereas meteors break up as if they were as soft as snowflakes, O'Keefe says.

If a few meteors can be captured in



LUNAR surface, atmosphere, magnetic field could be measured first with hard-landing penetration spike, left; or semi-hard impact vehicle at right. Soft-landing vehicle, center, using retrorocket to lessen shock to payload, would follow.

space and returned to earth for study, it should be possible to determine a great deal more about the physical composition of comets.

O'Keefe speculates that violent explosions on the moon may hurl lunar samples onto the earth, but there is no way of identifying them as such at present. If a lunar probe vehicle could bring back only a small sample of the moon's surface, it would enable scientists to identify lunar materials from other extra-terrestrial samples.

Acknowledging the difficulty of obtaining a lunar sample, O'Keefe said that it would provide the missing link between "something we know in a museum and something we see through the telescope."

The earth's atmosphere has long denied scientists much more than a limited peek at planets and the stars because it diffuses visible light and passes only a small portion of the electromagnetic radiation spectrum. By placing a telescope and/or other electromagnetic radiation sensitive devices in a satellite above earth's atmosphere, scientists can greatly expand their present knowledge.

With access to gamma rays and X-rays, for example, it should be possible to learn more about the sun's corona and the origin of cosmic rays. Between the region of visible light and the radio gaps, scientists will gain access to molecular radiation, which may reveal the composition of the moon's surface, or whether life exists on Mars.

Access to the relatively long radio wavelengths now blocked by the ionosphere may reveal details on the motion of very large gaseous masses and of galaxies as a whole. "Perhaps in this region we would be able to find the remotest parts of the universe," O'Keefe speculates.

The earth's ionosphere, the spherical shell of charged (ionized) atmospheric gases extending from an altitude of about 40 mi. out to tens of thousands of miles, provides the vital mechanism by which high frequency radio waves are reflected around the earth. Regular 24-hr. cycle changes in the ionosphere sharply alter radio propagation, and sporadic changes can completely disrupt radio communications.

Before the advent of satellites and sounding rockets, scientists had pieced together a limited picture of the ionosphere from earth-based radio soundings. It was believed that ultraviolet rays from the sun produced maximum ionization during daylight hours at four distinct altitude levels: the D-region from 35 to 50 mi., the E-region at 60 mi., the F1-region at 120 mi. and the F2-region at about 180 mi. At night the two F-regions merge and the E-region becomes patchy in nature, while the D-region disappears entirely.

In the Arctic and Antarctic, sunspot activity was known to produce marked changes in the ionosphere, with serious disruption of radio communications. But the real cause and effect relationship was defined only by speculation.

During the International Geophysical Year, rocket probes in the Arctic revealed that the disturbed low-altitude D-layer ionization was due to X-rays from the sun, not ultraviolet radiation as earlier supposed, according to Dr. John F. Clark, chief of NASA's planetary sciences programs. This prompts the hope that it may be possible to forecast disruptions in Arctic communications well in advance of their occurrence—an important gain for vital military applications.

Scientists also learned that the entire ionosphere is a connected region with only minor variations in the density of charged particles, and not a series of layers with deep valleys separating them, Clark said.

Soviet satellite and rocket data confirmed that the density of charged particles above the F-region maximum decreased far more slowly than had been believed. The density of electrons exceeds 10,000 per cubic centimeter from 100 mi. to 1,000 mi.

This indicates that the bulk of the ionosphere lies above the F2-region at 180 mi. altitude, not below it as previously thought. Therefore the ionosphere may have a greater effect on communications between space vehicles and earth than had been anticipated.

Research Objectives

NASA's ionosphere research program objectives include the following:

• **Source and nature** of the ionosphere and its composition. NASA hopes to pin down whether ultraviolet, X-ray or other radiation is the mechanism responsible for each portion of the ionosphere. In the E-region, nitric oxide is believed to be the predominant charged particle, and atomic oxygen in the F-region. NASA will seek to establish other constituents of the ionosphere and determine how they vary with time and location.

LATER vehicles will explore planets, send payload back by means of takeoff rockets, use retrorockets to land on earth.

• **Ionized region structure** above 200 mi. altitude will be investigated by means of satellite and space probe measurements as well as by radio propagation through the medium. The goal will be to map variations in density and composition as functions of time, season, latitude and sunspot activity.

NASA also is interested in investigating other ionized regions in the solar system, including those that may exist around the moon and other planets. This will be important in establishing optimum radio frequency for communicating with space probe vehicles, to prevent black-out of communications when the space vehicle enters planet's ionosphere.

There are important reasons for iono-

Atmospheres—Two-Year Program

Purpose	Launchings
Pressure, density, temperature and composition of atmospheres of Venus and Mars	1 space probe
Density and composition of interplanetary space and the moon's atmosphere	1 space probe
Pressure, density, temperature and composition of the earth's atmosphere above 100 mi. from the earth's surface	3 satellites
Pressure, density, temperature, composition and winds in the region between 50 and 100 mi. above the earth's surface	40 sounding rockets
World-wide survey of pressure, density, temperature, composition and winds up to 30 mi. above the earth's surface	40 sounding rockets

Magnetic Fields—18-Month Program

Purpose	Launchings
Magnetic storm currents, radiation belt currents	2 satellites
Space map of earth's field, disturbance sources, wave phenomena	1 satellite
Moon's field, interplanetary fields, earth's "far field"	1 space probe
Ionospheric currents, instrumentation tests	30 sounding rockets
Hitch-hike experiments:	
Field of Venus	2 space probes,
Interplanetary fields	2 satellites
Distortion of earth's field	

sphere investigations aside from the radio communications problem, Clark points out. A vehicle moving through ionosphere may accumulate a sizable electric charge which could slow down the vehicle or introduce a significant error into its trajectory. Accumulated charge also could prove a problem if electrical measurements are to be made from the surface of the vehicle.

Canada has volunteered to design and fabricate a "topside sounder" satellite that will explore the ionosphere from above in a novel experiment. When the satellite, orbiting above the ionosphere, receives a trigger pulse from an earth station, transmitted at a radio frequency that can pass through the ionosphere, it will transmit a signal at a lower frequency, which will be reflected back from the ionosphere to the satellite. The satellite then will radio back the data on a higher frequency which can pass completely through the ionosphere to reach the earth station.

Simultaneously the earth station will be bouncing a lower frequency signal off the underside of the ionosphere, providing a profile from both above and below.

Canadian interest in the ionosphere is whetted by the fact that much of the country is in the auroral zone and is subject to frequent outages in long-range communications. The United States will provide the satellite booster and Canada will supply the satellite and ground-based equipment. Clark calls this "a most effective type of international cooperation and a highly valuable means for broadening the base of total space research effort."

During the next two years, NASA plans to launch approximately seven sounding rockets, five earth satellites and one space probe experiment directed toward ionospheric research.

Possibility of establishing a propagation observatory on the moon also is under consideration, Clark said. Such an observatory would be extremely useful in monitoring the cosmic noise that provides unwanted background against which interplanetary communications must operate. A lunar observatory also would permit investigation of one-way propagation through the earth's ionosphere on a continuing basis.

A lunar relay station also may be required for communication with interplanetary space vehicles if it proves necessary to use very low frequencies, which can not penetrate earth's ionosphere, to operate over these extended distances. Earth signals would be transmitted at higher frequency and rebroadcast on low frequencies from lunar relay.

Reverse conversion is required for space vehicle signals to reach earth.

Cosmic Radiation

Within the next 18 months, NASA hopes to launch two satellites and four sounding rocket experiments to map more precisely the extent of the Van Allen radiation belts and to determine the types of particles involved, according to Dr. Leslie H. Meredith, head of NASA's fields and particles branch. Present speculation is that the inner belt consists predominantly of decay products of neutrons produced by proton bombardment of earth's atmosphere and that the outer shell consists primarily of electrons.

NASA also plans a satellite and two space probe experiments in the next 18 months to measure cosmic ray intensity in interplanetary space. Another satellite experiment will seek to measure cosmic ray intensity variations as a function of time. One space probe experiment and two sounding rockets will measure cosmic ray energy and charge spectrum, according to Meredith. From these experiments may come the answer to where these high energy particles originate.

The sounding rockets launched during IGY from Ft. Churchill, Canada, were the first to be fired into visible auroras. They showed that the auroras are produced by electrons striking the earth's upper atmosphere, Meredith said. NASA plans to fire 12 small rockets in the next 18 months for further determination of the nature of the particles responsible for the aurora.

Using sounding rockets, satellites and space probes, NASA plans to increase current knowledge of the earth's upper atmosphere, then extend this quest to the atmosphere of the sun, planets and the moon, if a lunar atmosphere exists.

One reason NASA is interested in examining the atmospheres that may be found elsewhere is to give scientists a broader perspective. "We may see things in our earth's atmosphere that we did not see before," according to Dr. Homer E. Newell, Jr., NASA's assistant director for space sciences.

At the top of the earth's atmosphere, scientists expect to find its constituents separating out, with the lighter gases drifting upward and the heavier ones settling downward, according to Dr. Newell. The reason this "diffusive separation" takes place here but not at lower altitudes is because of the mixing, turbulent motions at lower altitudes.

"We don't understand the weather of the upper atmosphere," Newell says. "We are interested in learning about the effects of sun, the effects of geographic position and season, the nature of the winds and other factors in the upper atmosphere."

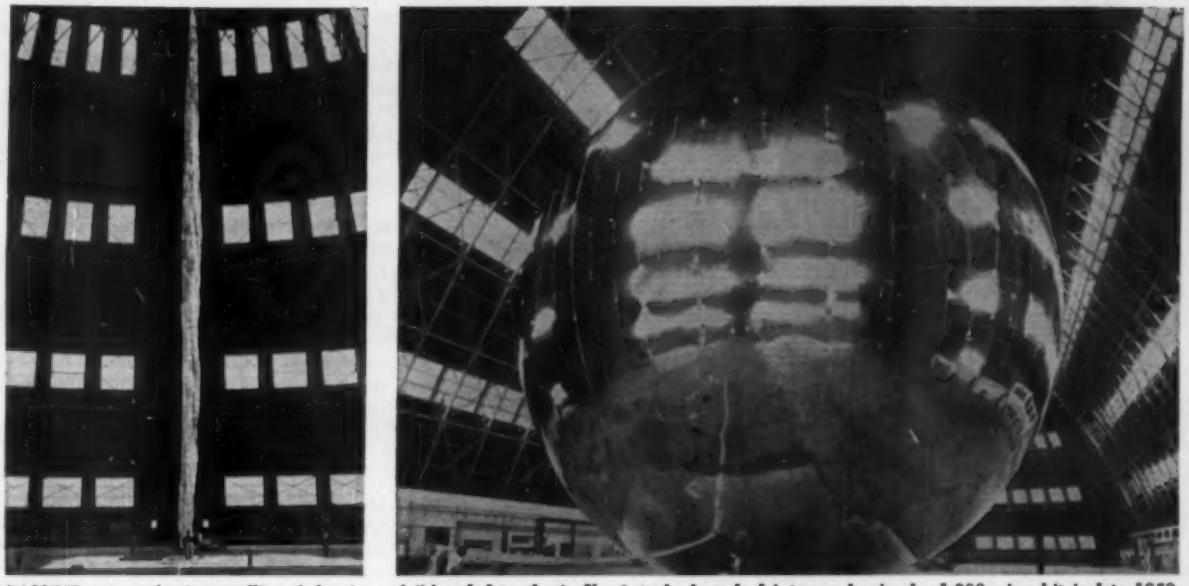
NASA also hopes to determine whether there is hydrogen in the top layers of the atmosphere, and whether it joins in with the hydrogen atmosphere of the sun.

In the next two years, NASA plans three satellite experiments to study the earth's atmosphere, pressure, density, temperature and composition. There will be two space probes, one to measure density and composition of interplanetary space and the moon's atmosphere, the other to make similar measurements of the atmosphere of Venus or Mars. The latter probe is two or three years away, Newell indicates.

In the next 18 months, NASA hopes to fire approximately 140 sounding rockets to measure pressure, temperature, density, composition and winds at altitudes of 50 to 100 mi., with another 40 rockets planned for similar measurements at lower altitudes.

Gravitational Fields—Two-Year Program

Purpose	Launchings
Geodetic measurements:	
Earth's shape and size	1 satellite
Intercontinental distances	
Test of general theory of relativity using atomic frequency standards	1 satellite



PASSIVE communication satellite of aluminum foil bonded to plastic film is to be launched into nearly circular 1,000-mi. orbit in late 1959 or early 1960. Sphere, shown deflated and inflated in Langley hangar, inflates in orbit.

Operational Satellite Network Planned

An ambitious and expanding program to develop the basic techniques required to provide the nation with an operational network of communication, meteorological, geodetic and navigation satellites for civil and joint civil-military use within the next 10-15 years is under way at the National Aeronautics and Space Administration.

The satellites coming out of these programs and those which the Advanced Research Projects Agency is sponsoring primarily for military applications, will have a major impact upon the nation's way of life, its commerce and its defenses.

NASA and ARPA coordinate their respective areas of satellite development in order to explore all possible avenues of approach, within budget limits, without duplication of effort. Satellites for strictly military applications, such as the infrared-equipped early warning Midas, are under ARPA. But the meteorological satellite program, originally started under Defense Department sponsorship, has now been turned over to NASA because it will have civil applications in addition to military uses.

In the communication satellite area, NASA presently is concentrating on the passive or reflecting type of satellite, while ARPA is working on the active satellite relay type (AW April 27, p. 28). This is not necessarily a permanent line of demarcation, since both agencies have indicated an interest in both types.

NASA is holding off on its own navigation satellite program until ARPA and Defense Department decide whether their own military navigation satellite will be designed to serve both military and civil users, or will be limited to military users for security reasons. If the latter happens, NASA may launch a program for a civil navigation satellite.

First experimental passive communication satellite presently is scheduled for late 1959 or early 1960. It will consist of a 100 ft. diam., metal-coated inflatable plastic sphere. The 65-lb. sphere will be packed in a small spherical container measuring approximately 30 in. in diameter. Once in orbit, the container will open and water inside the plastic sphere will begin to boil, due to heat from solar radiation. This will produce steam that will expand the sphere to its full 100-ft. diameter.

Present Plans

Present plans are to launch the satellite on a 50-deg. inclined orbit, with a goal of achieving a nearly circular 1,000-mi. orbit, according to Leonard Jaffe, who heads NASA's communications satellite program.

Jaffe emphasizes that the first passive satellite, and others to follow, will be experimental in nature, intended to determine the feasibility of using inflatable, non-rigid spheres and to investigate propagation characteristics at several different radio frequencies.

NASA hopes to get universities and industry groups to participate in tests on a voluntary basis, to fill out propagation data in portions of the spectrum where the agency will not be operating.

Present plans call for NASA tests to be conducted in the 1,000 to 2,000 mc. region.

This points up an important advantage of a passive satellite. A large number of users in different locations can bounce radio signals off the satellite simultaneously without interfering with other users, providing each operates at a different radio frequency.

Other advantages include:

- **Wide bandwidth**—Passive satellite offers practically unlimited bandwidth, making it suitable for transmitting photographs and television.
- **Simplicity, reliability**—Lack of avionics equipment on board the satellite itself eliminates problem of achieving long trouble-free operation in the space environment and the problem of generating electric power in the vehicle.
- **Flexibility**—Operating frequency and/or mode of operation can be changed after the satellite is in orbit simply by modifying ground equipment.

The passive satellite has certain attendant disadvantages, however. For instance, large, high-gain antennas, powerful transmitters and extremely sensitive receivers are required on the ground. From a military standpoint, active communication satellites—par-

ticularly the courier type (delayed relay)—offer more privacy than a simple passive reflector.

But for civil and some military applications, passive satellites appear very attractive. For example, if trans-Atlantic communications continue their present growth, the cable installed in 1956 may reach its full capacity by 1962, according to Jaffe. An advanced transistorized cable now under development, with twice this capacity, also may be saturated quickly. Passive satellite relays can provide required future capacity, and at considerably less cost than by submarine cable.

Future Goals

If the simple inflatable plastic sphere proves unable to withstand micrometeorites or other rigors of the space environment for extended periods, NASA plans to investigate other configurations, including the use of an inflatable ring to provide a more rigid structure.

NASA also is anxious to launch a passive relay satellite in a polar orbit in order to investigate the propagation problems which may be encountered in the high latitude auroral regions. If the first experiment early next year is successful, the second launching may aim for a polar orbit.

The next phase of NASA's program calls for attempting simultaneous launchings of multiple spheres from a single booster. By placing a sufficient number of passive satellites in orbit, either with synchronized or random spacing, it should be possible to eliminate the need for using costly steerable antennas on the ground and assure that one or more satellites is always in view of the ground stations.

When larger boosters become available, NASA will then shoot for the 22,400-mi. high equatorial orbit in which the satellite effectively hovers over one spot on the earth, since both the satellite and earth are rotating at the same speed. This will pose new problems in constructing an inflatable satellite because of the proportionately larger reflecting surface required at the 22,400-mi. altitude. Present estimates indicate that a sphere measuring perhaps one quarter to one half mile in diameter may be needed.

By the end of this year, NASA hopes to launch the first of two 250-lb. meteorological satellites known as Tiros —Television Infrared Observation Satellite. Combination of a tiny TV camera and infrared sensors in the 40-in. diam. satellite will measure earth cloud cover, earth and cloud temperatures and incoming solar radiation. Satellites are being designed and fabricated by Army Signal Corps' Research and Development Laboratories, Radio Corp. of America and others.

The experimental Tiros satellites are prototypes of a system of satellites which meteorologists believe may well revolutionize the science of weather forecasting and perhaps open the way to some measure of weather control.

At present, meteorologists can only sample the weather around the globe using radiosonde weather balloons launched from approximately 400 stations located primarily in populated areas. Vast sections of land mass in South America and Africa are nearly void of stations. Because weather ships are expensive to operate, only sparse data is available from the two-thirds of the earth's surface covered by water. The over-water gaps in coverage are particularly important in areas like the Atlantic Ocean, breeding ground for the hurricanes that strike the eastern seaboard and gulf coast.

Although meteorological satellites probably will not replace earth-based observations, they will provide meteorologists with an integrated global picture of weather conditions instead of requiring extrapolation from a few sample measurements.

Present objective of the NASA meteorological satellite program is to develop a system that will, if at all possible, meet the needs of both civil and military users, according to Dr. Morris Tepper who heads the program. (Tepper is a meteorologist, formerly with the Weather Bureau.) A Joint Meteorological Satellite Advisory Committee has been formed recently, with representatives from Defense Department, Weather Bureau and NASA, to try to incorporate requirements of all users into the NASA program.

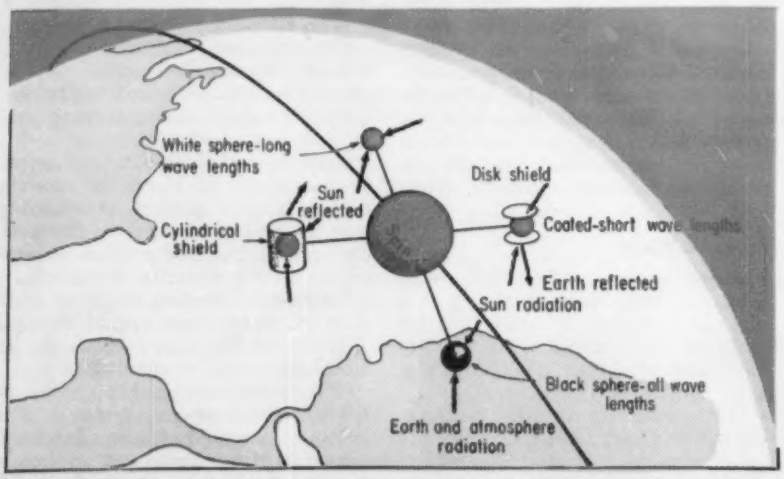
Dr. Tepper emphasizes that meteorologists will have to develop new techniques for using meteorological satellite data, since such information has never before been available. Thus satellite designs and meteorological techniques must be developed with close coordination between vehicle designer and data user.

Proposals To Be Sought

The Tiros satellites will be spin-stabilized in space, which means that the tiny TV camera in the bottom of the satellite will look down on the earth only for a portion of an orbit and will be peering out into space during the rest of each orbit. What is required for an operational meteorological satellite is a vehicle that is earth oriented so that its optics will continuously look down on the earth as the vehicle orbits. This is one of the objectives of NASA's future development program.

Within the next several weeks, NASA hopes to ask industry for proposals on a lightweight radar suitable for use in a meteorological satellite to measure the amount of precipitation in clouds, using the same principle now employed in airline weather radar. The task is not an easy one because of the extremely light weight, small size, low power consumption and reliability required for such a satellite. Tepper hopes industry can develop a suitable satellite weather radar within a couple of years.

Within the next 10 to 15 years, NASA believes, it will be possible to have a global network of meteorological satellites in operation. The network would consist of low-altitude satellites in polar orbit at an altitude of perhaps 500 to 800 mi. From the viewpoint of meteorologists, a polar orbit is ideal because the satellite reports weather data for the same local time (longitude) throughout one orbital sweep, greatly simplifying subsequent data analysis. Series of satellites in polar orbits, separated in longitude, could provide a complete picture of



HEAT BALANCE satellite will measure exchange of heat between earth, its atmosphere and space beyond atmosphere. Two launch attempts are planned by midsummer.

global cloud cover every two hours or less.

NASA also envisions a series of three or four hovering weather observatories in 22,300-mi. equatorial orbits. These would be equipped with TV cameras and radar which could be aimed by remote control for a close look at any desired portion of the global weather.

Cloud cover and heat balance data in the polar orbit satellites would be stored on a tape recorder, then transmitted to an earth station each time a satellite came within range. However, for satellites passing over unpopulated areas, it may prove necessary to employ communication satellites to relay the data back to central Weather Bureau computers while it still is fresh.

Geodetic Satellite Contracts

NASA soon will award preliminary design contracts for a geodetic satellite which it hopes to launch in approximately 18 mo. The geodetic satellite will be equipped with a series of high-intensity flashing lights which should give it the brilliance of a fifth order of magnitude star at an altitude of 800 to 1,000 mi.

The satellite is expected to permit a more accurate determination of the size and shape of the earth, which has important implications for accurate guidance of intercontinental ballistic missiles because of its effect on nose cone trajectory.

Equally important, the geodetic satellite should make it possible to reduce the error in determination of distances between cities in different continents from approximately 1,000 ft. to perhaps 200 ft. This is important also for ICBM guidance inasmuch as guidance errors of less than 1,000 to 1,500 ft. are the objective for future missiles.

Present errors arise because of inability to use optical or accurate radio surveying techniques across large bodies of water and the inaccuracies in astronomical measurements which result from errors in local vertical at widely separated points due to earth's oblateness.

Several techniques for using a geodetic satellite now appear promising, according to Benjamin Milwitzky who heads NASA's geodetic and navigation satellite effort. One method, called the geometric technique, can be used where the satellite can be simultaneously viewed from two points on each of the two geodetic networks whose relative positions are to be determined. A satellite in orbit at 1,200 mi. altitude should be visable from two points on the earth several thousand miles apart.

Using the geometric method, photographs are taken simultaneously of the flashing-light satellite from two points on one geodetic net and from two points on the other, with the stars providing a reference background. This provides a line-of-sight from each of the four points to the satellite. By means of triangulation and using the known position of the celestial sphere (stars) at the instant the photograph was taken, it is possible to compute distances and relative orientations of the two geodetic nets, Milwitzky explains. Technique has the advantage of not requiring precise information on the exact position of the satellite or its orbital characteristics and is independent of errors in local vertical due to earth's oblateness.

To perform similar correlation for two geodetic networks where the satellite can not be simultaneously viewed from points on each network, an orbital extrapolation technique appears feasible. Knowing the period of the satellite orbit and the time it requires for the earth to rotate sufficiently for the satellite to come into view of a second set of stations makes it possible to compensate for relative movement of earth and celestial sphere in performing triangulation computations.

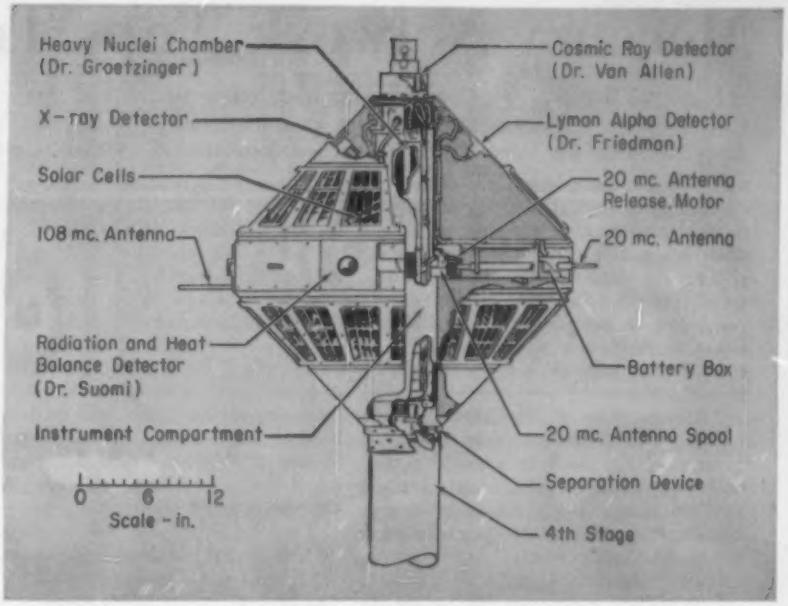
To determine the precise shape of earth from geodetic satellite, its orbit will be determined to show perturbations from an idealized elliptical orbit. Then scientists will work backward to determine what sort of earth shape would produce such perturbations.

There are far more problems involved in design of a geodetic satellite than first meets the eye, Milwitzky points out. For example, approximately 50 watts of electrical power will be required to develop the required brightness of the discharge lamps, according to present estimates. This will require many silicon solar cells, with batteries to store the energy for use when the satellite is on the dark side of the earth, plus banks of capacitors to provide brief, high peak power required for the one millisecond duration lamp flash. This is considerably more power than has been required to operate satellite tracking and telemetry transmitters.

Internal temperature of the satellite must be maintained within reasonable limits to assure reliable operation of the batteries and capacitors. Present plans are to use dark and light external surfaces on the satellite to control the amount of solar heating and satellite heat radiation. The technique has proven very successful in previous satellites, yet adds practically no weight or complexity. This poses a difficult design trade-off problem, since the maximum possible external surface is desired for solar cells—yet this must be balanced against temperature control requirements.

Another problem area is the design of high intensity discharge lamps and protective quartz windows which are small and rugged enough to withstand the high shock and vibration encountered during satellite launching.

The current NASA plan is to contract out individual portions of the satellite to specialists in their fields rather than to award a single integrated package contract. Some elements will be designed and fabricated in-house by NASA's Jet Propulsion Laboratory and by former Project Vanguard scientists. Once the basic design has been established and proven, subsequent models might be contracted as a package.



SATELLITE originally planned for International Geophysical Year by Army Ballistic Missile Agency combines six experiments, will be launched in near future.

Mercury Network Tops Tracking Needs

National Aeronautics and Space Administration's current and projected space program will require tracking, data acquisition and processing facilities designed to handle three basic types of missions—man-in-orbit, unmanned satellites and deep space probes.

The most critical and urgent need is the creation of a suitable tracking, data acquisition and communication system for NASA's Mercury man-in-space project. NASA's choice of a contractor to integrate and expand existing facilities into the required Project Mercury network is expected to be named soon.

Mercury poses many difficult new tracking and communication problems because of the need to provide maximum assurance of pilot safety during the critical launch and recovery phases. Extremely precise guidance and tracking is required during launch, with speedy computation of orbit, so that an emergency abort can take place if necessary in a portion of the Atlantic where rescue craft will be available.

Existing Minitrack stations, which require a number of satellite passes in order to determine an orbit accurately, will not be adequate for the Mercury capsule, which is expected to re-enter after no more than three orbits and perhaps after only one on initial flight.

An inclined northeast orbit has been selected for the Mercury capsule for several reasons. Such an orbit will keep the satellite over friendly countries. Equally important, each orbit will bring the capsule over the southern portion of the U. S., where many tracking radars already exist. This assures that the capsule will land in a comparatively well-instrumented area of the Atlantic Missile Range.

If the more conventional southeast orbit were used, the capsule might land in the dense jungles of Central America, making speedy recovery difficult.

Atlantic Missile Range down-range tracking facilities will be usable during orbit and recovery phase, but not during initial launch. This will require installation of a precision tracking radar, data acquisition and communication facilities in Bermuda. This major new $1.3 million facility will also serve as a permanent down-range station for satellites subsequently launched from NASA's Pilotless Aircraft Research Station at Wallops Island, Va., according to Edmund C. Buckley, who heads the space flight operations group.

Tracking radars also will be required in Hawaii and Texas for re-entry, but the question of whether existing radars can be used still is under study.

Existing Facilities

NASA will use existing military tracking, data acquisition and communication facilities wherever this can be done without interfering with high priority military programs or seriously delaying Project Mercury, Buckley said. A joint Defense Department-NASA committee has made an inventory of all existing facilities as well as all military and NASA programs requiring facilities, to determine where gaps exist and to prevent duplication.

New telemetry and communications facilities required for Mercury will be installed in mobile vans wherever possible to permit them to be shifted later to other sites for future NASA programs, according to Francis B. Smith, chief of tracking programs. Shipboard installations are planned to provide coverage in portions of the Pacific and Indian oceans.

Most of the new facilities will be used to provide continuous radio contact with the Mercury capsule and its passenger. Data on the status of both the vehicle and its passenger will be telemetered down, where it will be monitored by both an engineer and a physician, ever alert for a malfunction that would require an emergency recovery.

Brief summary reports on the status of the capsule and passenger will be radioed back to NASA headquarters at Washington, D. C., and to control central at the Atlantic Missile Range.

Tracking data will be continuously transmitted back to NASA's computation center in Washington for precision calculation of orbit and prediction of the recovery area when re-entry is initiated.

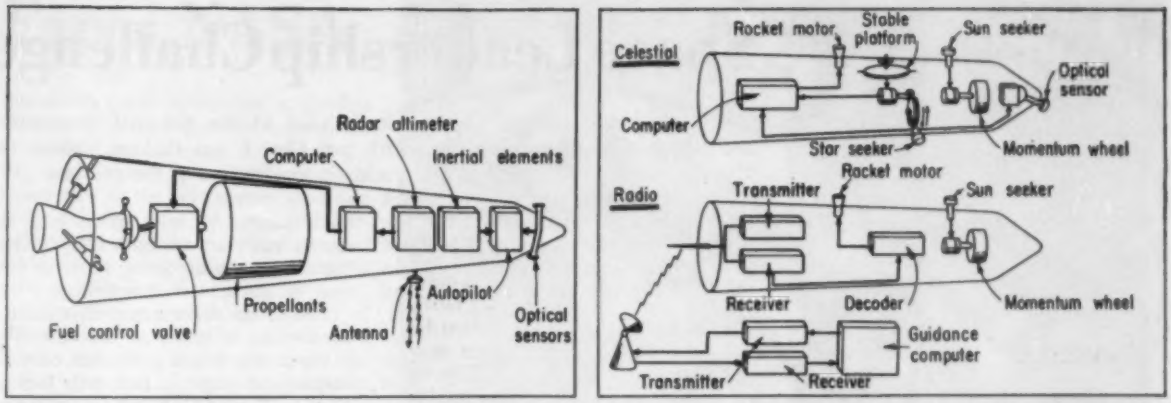
During Fiscal 1959-60, NASA plans to add four additional Minitrack stations to the 12 originally set up for International Geophysical Year satellite program. Because no high-inclination orbits were planned for IGY, present stations are located between 35 deg. north and south latitudes. The four new stations—in Newfoundland, Alaska, north central U.S., and Western Europe—will extend high latitude coverage.

Existing Minitrack stations will be modernized to provide real-time digital data read-out equipment and additional antenna arrays to extend their coverage for high inclination orbits. In addition, older stations will be shifted to a new operating frequency, probably around 135 mc., when the present temporary 108 mc. frequency assigned for IGY is withdrawn.

To provide continuous (24-hour) tracking coverage for deep space probes, NASA plans to spend approximately $3.5 million during the coming year to

Approximate Injection Guidance Accuracy Requirements

Types of Missions	Allowable Error at Injection		Remarks
	Angle (deg.)	Speed (mph.)	
Minimum guidance accuracy	2 to 3	100 to 500	Requirements can be met with equipment available.
a. Simple elliptical orbits			
b. Minimum altitude			
Improved accuracy needed			Equipment in advanced development stages will satisfy requirements.
a. Specific elliptical orbits	½ to 2	25 to 50	
b. Nearly circular orbits			
Precision guidance			Precision guidance in upper stages required. Also, supplementary radio links or terminal guidance.
a. 24-hr. circular orbit	0.1 to 0.25	1 to 2	
b. Transference orbit			



NUMBER of approaches to terminal guidance, left, and midcourse navigation systems for use in interplanetary flight are being studied by NASA. Guidance, right, may be celestial-inertial or radio command, an extension of current launch guidance.

set up two stations, each one-third of a globe away in South Africa and in Australia. Each new station, similar to one now in operation at Goldstone, Calif., will be outfitted with an 85-ft. dia. movable parabolic antenna and sensitive receivers for tracking signals transmitted by space probe vehicles. NASA's Jet Propulsion Laboratory will be responsible for implementing the two new facilities. Defense Department plans to install similar facilities in Japan and in Spain for its own military space tracking needs.

Providing reliable communications between earth and planetary probes will be a problem of great magnitude, according to Leonard Jaffe, who heads NASA's communications satellite program. Reason is that radio signal strength falls off as the square of the distance—a major consideration with the tremendous distances involved in interplanetary missions.

It would be desirable to transmit back a continuous television picture of Mars from a probing vehicle but this would require millions or billions of watts of vehicle transmitter power—clearly an impossibility in terms of today's knowledge and the payloads that can be carried in the foreseeable future.

By transmitting back only a still picture at periodic intervals, storing the picture on a tape recorder in the vehicle for slowed-down transmission, and using a large, steerable antenna that the vehicle can point at the earth, the required power can be reduced to the order of 10,000 watts. This still is an extremely imposing figure for a space vehicle to provide, but it is within the realm of possibilities when nuclear propulsion comes into use.

It is evident that early interplanetary probes are going to be severely restricted in the amount of information that can be radioed back to earth. NASA currently is studying the basic problem of how much and what types of information will be required as a bare minimum. Much of this effort is under way at NASA's Jet Propulsion Laboratory.

Another important problem area is that of developing high-gain steerable antenna designs suitable for space vehicle use. Antenna must be able to be erected after launching with high degree of reliability.

Jaffe says the space probe vehicle communications problem is so imposing that a technological breakthrough may be needed to provide a useful solution. He adds that NASA is interested in hearing any good new ideas that scientists and engineers might suggest

Space Probe Guidance

Advent of larger payload boosters, like the Vega and Centaur, will offer the first opportunity to use sophisticated midcourse and/or terminal guidance equipment aboard the vehicle itself.

The capability provided by such midcourse and/or terminal guidance, compared to the inflexible launch-guidance now employed, is equivalent to the flexibility of a guided missile compared to an anti-aircraft shell.

NASA scientists currently are studying different possible approaches to the problem with the objective of creating a program to develop midcourse and terminal guidance techniques and systems. It has received a number of proposals from industry, but says its budget will not permit a "shotgun approach." For this reason it is working closely with Wright Air Development Center's Flight Control and Weapons Guidance Laboratories to prevent duplication of techniques which WADC is sponsoring.

Two basic approaches to midcourse guidance which have been proposed are:

• **Celestial-inertial**—Optical or infrared sensors would be used to lock onto the destination planet and other planets to provide an angular reference for measuring the vehicle's movement through the solar system. A computer in the vehicle would compare actual flight path with the desired trajectory and develop corrective signals which would be applied to reaction wheels to alter the vehicle's heading. A gyro stabilized platform within the vehicle would provide short-term spatial stability so that brief disturbances of the space vehicle would not cause optical trackers to lose sight of their targets.

• **Radio command**—This is an extension of present launch-guidance techniques, with vehicle trajectory being computed by earth-bound stations and corrective commands being radioed to the vehicle.

For terminal guidance, the use of infrared or optical horizon-scanners, to determine location of the planet's horizon and approximate distance to landfall by stadiametric ranging techniques has been proposed. Another possibility is the use of a radio/radar altimeter for measuring rate-of-closure and altitude.

Although a number of existing techniques appear applicable, the real problem is to reduce them to a practical, reliable system which is small enough and light enough to fit inside the allowable payload limits. Even for a rough lunar landing, which is a rather unsophisticated mission, the Vega will be limited to a total payload of about 650 lb., according to present estimates. Only a fraction of this total will be available for midcourse and terminal guidance.

What is needed is a systems integration effort in combination with design ingenuity to come up with a system whose components serve multiple functions during initial launch, midcourse and terminal guidance phases, according to one NASA scientist.

In the coming months, NASA hopes to launch some preliminary studies and developments in the space probe guidance area, recognizing that the lead time required to develop such techniques and equipment may prove longer than that required for the boosters that will carry the payloads.

Space Leadership Challenge

T. KEITH GLENNAN
Administrator

HUGH L. DRYDEN
Deputy Administrator

The challenge and the opportunity handed to the National Aeronautics and Space Administration at its birth last Oct. 1 was that of leading the United States—and hopefully, the world—in exploration of the universe.

Few challenges could have been more formidable, particularly when the mandate implied that the U.S. must overtake and surpass a competing nation that had the advantage of a fast head start.

Sound, logical, scientific progress would have led man into space exploration eventually, but without the press of time suddenly imposed by the political and military implications inherent in Soviet Russia's impressive progress in the field.

NASA Administrator T. Keith Glennan, whose many tasks since last October have included convincing Congress that strong financial support of a space program is necessary, told one committee:

"Man has always been curious about his environment and his natural curiosity is going to carry this program forward, I think, without any question. Whether it will be carried forward at the pace that it has been carried forward is quite another question.

"Here we find ourselves in competition with another nation that is really forcing our hand to a considerable extent; that is, at least as to the manner in which we go about it, the pace at which we go about it."

Deputy Administrator Hugh L. Dryden, who headed the aeronautical research organization that became the nucleus of the space agency, told the same Congressional group:

"We have mentioned some possible commercial applications (of space exploration). We think, as a matter of faith again, that we are going to have men going out into space, and the sooner you start to study the problems the sooner you are going to be in position to consider such activities.

"Now, the difference is that there is another set of zeros on the cost. This is expensive; it is a game that only big nations can play. In fact, only two nations in the world today are in a position to support this kind of a program, and I feel, as many others do, that if we are not willing to do it, there is a nation that is going to do it, whether we do it or not."

Frankness Praised

This kind of frankness about the potential promise of space exploration, the need for doing it as rapidly as possible, and the great cost of undertaking it has run throughout NASA's brief history. It has been accepted—and praised—by committees of Congress.

Whether this rapport will continue will depend on how well the space program is conducted and how much it produces that is tangible enough for the Congress and the public to understand, how high the cost of the program eventually grows, and what degree of pressure is created by Soviet competition.

Glennan has estimated that the cost may reach $1 billion within a few years and $2 billion within six or eight years. Others have said this estimate may prove to be conservative. Regardless of the eventual size or cost, it is clear that it now is only in its infancy.

NASA has existed for only nine

RICHARD E. HORNER
Associate Administrator

ABE SILVERSTEIN
Space Flight Development Director

JOHN W. CROWLEY, JR.
Aeronautical-Space Research Director

Faces NASA

months. It has been working, as Dryden said, "with a high sense of urgency on a four-fold task—carrying out the on-going satellite and space probe projects transferred to the new agency, planning and initiating new projects, establishing long-range plans and objectives and building an organization adequate to carry out the overall program."

NASA began with a foundation of three major aeronautical, missile and space research laboratories and the 8,000 scientists, engineers and support personnel who ran them—the former National Advisory Committee for Aeronautics.

Along with this it inherited projects, dollars and trained personnel from other segments of government. Still more important, it began with a high degree of government approval and support that generally had been denied to space projects as late as the period immediately preceding Russia's Sputnik I.

The agency's first task, in addition to building its organization and planning a program, has been to insure that long lead-time items were begun immediately. In doing this it has taken under its supervision much of the old Air Force advanced propulsion program, added to it elements from Advanced Research Projects Agency and Army Ballistic Missile Agency programs, and laid out a national booster program that will provide a framework for the foreseeable transportation needs in space over the next 10 years.

This and the other initial steps in formulating a national space program probably have been the most painful the agency ever will have to take. In spite of top governmental backing, the agency has had to take away from others

PEBBLE bed heater at Lewis allows 5 min. blowdown at 3,000F at 20 lb./sec. of air for high Mach testing. It is located in chamber for simulating altitude conditions.

ALBERT F. SIEPERT
Business Administration Director

in order to fulfill its mission, sometimes at the risk of creating enmity. The close official and personal relationship between Glennan and Dr. James R. Killian, Jr., who was the President's scientific and technical advisor until recently, and respect for the old NACA's ability helped to some degree, but by no means did they make the way easy.

NASA absorbed the Navy's Vanguard satellite program and most of the Vanguard personnel, took over direction of some ARPA and Air Force work, acquired the Jet Propulsion Laboratory which California Institute of Technology had been operating for the Army, and attempted to acquire the Army Ballistic Missile Agency's scientific team. It lost the latter skirmish, at least temporarily.

From this beginning, the NASA program has grown into a real national program. Through the National Aeronautics and Space Council, NASA coordinates with representatives from the top echelons of government, science and industry including the President, State and Defense departments, Atomic Energy Commission, National Science Foundation and National Academy of Sciences. It also coordinates with Defense Department through the Civilian-Military Liaison Committee and with the scientific community through the science foundation, the National Academy of Sciences-National Research Council's Space Sciences Board, and a number of panels.

Its relationship with the military services, science and industry are fur-

MAGNETIC refrigerator at Lewis Research Center cools samples of materials to within ½ deg. K of absolute zero. Studies are stimulated by use of cryogenic fluids in rocket applications.

ROBERT R. GILRUTH
Space Task Group Leader

ther strengthened through advisory committees on specific fields of research and development, much in the pattern of the old NACA committees and subcommittees.

In spite of the mushrooming of its mission, NASA is attempting to remain as small and as flexible an agency as possible. It has continued the approach of the old NACA, which was to have a small fraction of its total personnel in a Washington, D.C., headquarters and keep strong technical teams in its field laboratories. NASA expects to have only 468 employes in headquarters by this time next year.

It now has four major laboratories—Langley Research Center at Langley, Va.; Lewis Research Center at Cleveland, O., Ames Research Center at Moffett Field, Calif.; and JPL near Pasadena, Calif.—and two lesser field stations, the Pilotless Aircraft Research Station at Wallops Island, Va. which is being expanded to handle larger rocket launchings; and the High Speed Flight Station at Edwards, Calif.

Construction will begin soon on the Goddard Space Flight Center at Greenbelt, Md., near Washington, D.C. It will serve as a basic research center, a development center for satellites, space probes and vehicles, tracking and communications and data reduction systems; and eventually as a command control center for space flight operations.

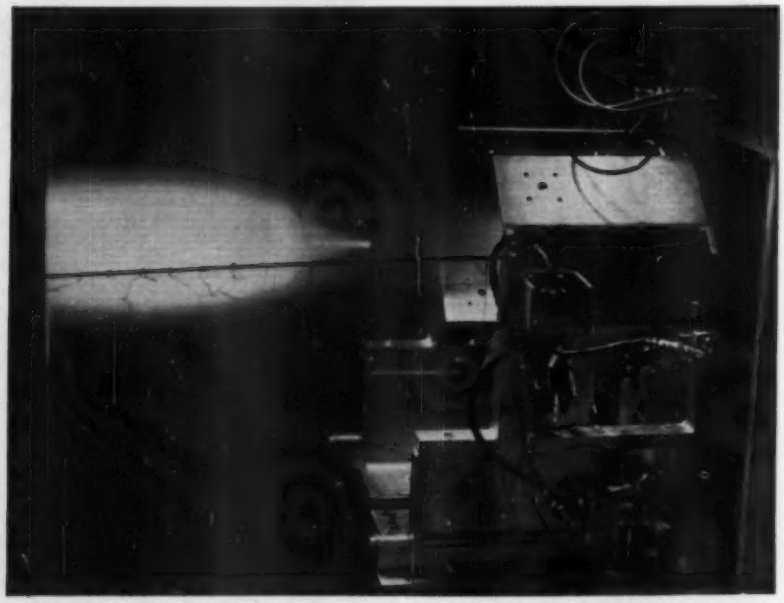
For its flight operations, NASA already is making frequent use of the Air Force Missile Test Center in Florida and will do the same at the Pacific Missile Range, Pt. Arguello, Calif.

Project Tiros, an advanced weather satellite, illustrates the phase NASA is in now—that of having inherited a going project involving government, science and industry, and having to follow it through and plan for future experiments.

Tiros will carry television cameras and a variety of radiation detectors to observe clouds, detect storms and measure in detail the heating of the atmosphere. One satellite will be launched by the end of this year and a second next spring. Beyond Tiros will come an attitude-controlled prototype of an operational weather satellite designed for a 700-mi. polar orbit.

Tiros itself was an ARPA-military project. It involves ARPA, Army Signal Research and Development Laboratories, the Weather Bureau, Air Research and Development Command's Cambridge Research Center, Ballistic Missile Division and Missile Test Center; Navy's Photographic Interpretation Center, the University of Wisconsin; Douglas Aircraft Corp., Space Technology Laboratories, Inc., and Radio Corp. of America, which is providing some components and handling assembly and testing of the satellite.

To direct these projects and plan new ones, Glennan and Dryden have in the headquarters organization an Associate Administrator, Richard E. Horner, former Assistant Secretary of the Air Force for Research and Development; an Office of Program Evaluation and Planning, headed by Homer J. Stewart, on leave from JPL; an Office of Aeronautical and Space Research, headed by John W. Crowley, Jr.; an Office of Space Flight Development,



SOLID rocket grain of 5,000 lb. thrust and 10 sec. duration is fired in high altitude, static air condition in altitude wind tunnel at Lewis to study ignition problems.

headed by Abe Silverstein; an Office of Business Administration, headed by Albert F. Siepert, plus supporting activities.

The research office has four main subdivisions—aerodynamics and flight mechanics, powerplants, structures and materials and aircraft operating problems; and an office of research grants and contracts, for seeking basic research contributions from individuals and educational and research institutions. The latter's $5 million budget is expected to double or triple in the next few years.

Space flight development is divided into advanced technology, propulsion, space sciences, space flight operations and program coordination.

While NASA intends to continue what Dr. Dryden calls "sufficient in-house effort to enable technical monitoring of the contract work," it decided as a matter of policy that development and operation of space vehicles and many of their payloads would be carried out largely by contract with industry, educational and governmental groups, and that industry, universities, NASA and other government laboratories would supplement this "by programs of basic and applied research to lay the ground work for future development."

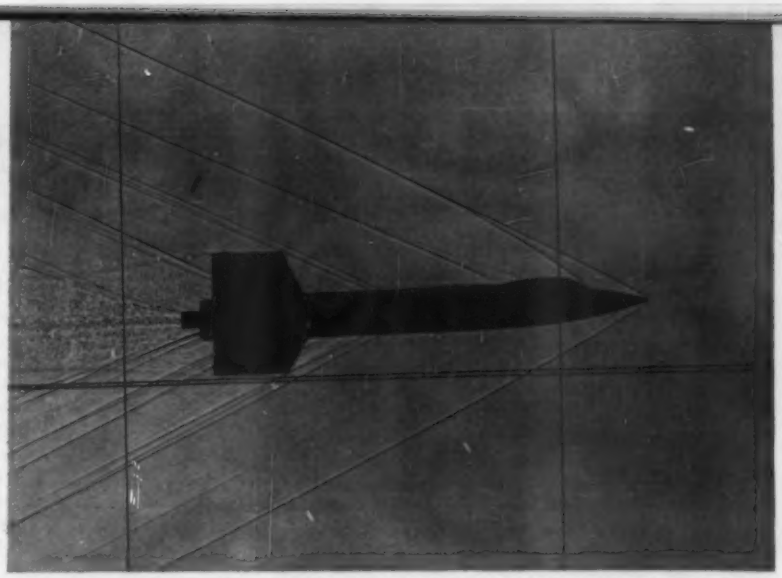
National Program

Since its inception last Oct. 1, NASA's national program already has met with setbacks. Of five planned lunar probes that NASA inherited, only one fulfilled its mission, although others gathered valuable information on the Van Allen radiation belts. Initial plans to launch a satellite with a 30,000 mi. apogee and 200-mi. perigee and two probes to the direction of Venus have slipped badly and the Venus shots could eventually be postponed for a year or more. The Vanguard program has been a disappointment.

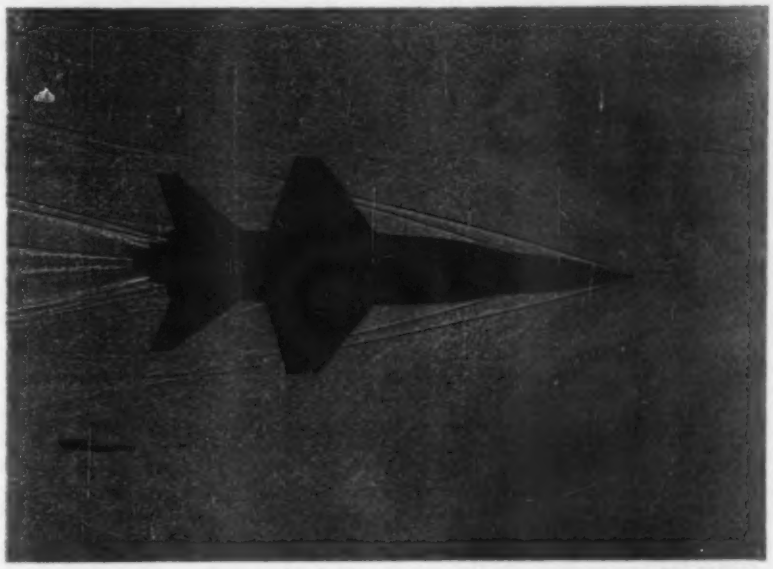
But a great deal of new scientific knowledge already has been gained about the earth's shape, its atmosphere, the radiation belts, etc. And most of the projects mentioned above were relatively hastily conceived experiments rather than parts of a comprehensive, long-range program of the type NASA is supposed to develop.

Following the launching of Sputnik I, initial criticism of the U. S. was that it had failed to recognize the value of and support space exploration as a high-priority, national effort.

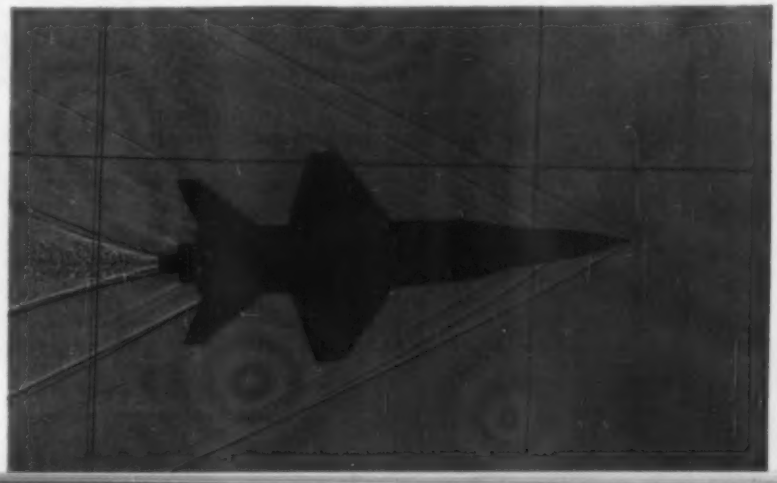
This now is being done, and the success of what is becoming an aggressive, integrated national program will depend largely on the foresight and the performance of the science-government-industry team that has had this challenge laid before it.



SHADOWGRAPH of 4.75 in. aluminum model of X-15 rocket research aircraft fired from gas gun at speed of Mach 2.5 in supersonic free flight wind tunnel at Ames Research Center. Grid permits accurate measurement of position and flight angle. Below, top view of model flying at Mach 6. Ames has conducted extensive tunnel program.



TOP VIEW of X-15 in same tunnel at Mach 2.5 shows flow pattern and pressure fields. X-15, built by North American Aviation, Inc., under a joint NASA-USAF-Navy program, already has made flights attached to Boeing B-52 mother ship and has begun free-flight glide program from Edwards AFB, Calif.



Industry Has Key Role in Space Work

The nature of a space program designed to explore vast new frontiers dictates that the money to finance it will follow a sharply rising curve.

The importance of this to industry already is evident in the first two budgets of the nine-month-old National Aeronautics and Space Administration. Of the $870 million total requested for Fiscal 1959 and 1960, $600 million will be spent for contracting. Some of this will be spent for research but the bulk of it is for development and procurement of space hardware.

The best indication that the spending curve will be forced upward rapidly as the space program grows out of its infancy comes from NASA's administrator, T. Keith Glennan. Glennan told Congress he believed that this year would be the last time his agency would ask for "as little as half a billion dollars."

"To try to go beyond this is really crystal balling," Glennan said, "but I would not be surprised to find within, say two years, that we might be asking for $1 billion in this program. Our viewpoint on that is that there will be a general level, if you will, of underlying space science investigations which will be funded year after year at a level-of-effort rate.

"What this will be I can't tell you now, but when one erects, on top of that base, specific programs such as the booster program I have suggested, it might cost as much as $2 billion in the next six or eight years. When one erects further such things as the man-in-space program . . . that probably will involve $200 million . . . one can see that this is apt to be an increasing program."

NASA's New Role

NASA was created around the nucleus of the old National Advisory Committee for Aeronautics. By the end of the 1960 fiscal year, it will have spent the equivalent of almost nine years of NACA budgets. Although the space agency still is primarily a research and development agency—developing new knowledge and techniques in its laboratories—it also has been turned into a contracting and operating agency.

Sixty-five per cent of its first year's budget and 72% of NASA's budget for the coming year will be paid out to educational, research and industrial groups. While no NASA official will predict how this percentage will change in the future, it seems likely that it will continue to increase. No great increase in laboratory facilities or personnel is foreseen, but procurement of space vehicles and payloads is sure to increase rapidly as development projects reach the useful stage.

To handle this suddenly-acquired assignment of selecting contractors and awarding and administering contracts, NASA has followed the same approach it used in putting together a national space program—it has made judicious use of existing organizations and procedures, trying at the same time to maintain a flexibility and independence of its own.

NASA is following the general pattern of research and development procurement that has been set by the military services, although there are some important differences.

One of the most important to larger industrial firms is that the agency is not adopting the system concept of procurement, except in certain crash programs where time is one of the most important considerations.

Under the systems approach, the entire assignment is handed to a prime contractor, who in turn selects and lets contracts to associate and subcontractors and is held responsible for the complete working of the entire program. A major drawback to this concept from the point of view of smaller firms is that the prime is inclined to keep in his own plant a great deal of work that might otherwise be done by a subcontractor.

Although none of the new projects begun by NASA uses the systems concept, the Mercury man-in-space project comes close because the urgency and priority are high enough that it might almost be considered a crash program, according to Ernest W. Brackett, who heads NASA's Procurement and Supply Division. For this reason, considerable reliance is being placed on the capsule contractor, McDonnell Aircraft Corp., for the capsule and some ground support and training equipment. Yet the Mercury project is not a true example of the systems concept because NASA is buying the boosters from Convair through Air Research and Development Command's Ballistic Missile Division, other test vehicles through Army's Ballistic Missile Agency, and still others direct from industry.

Typical Procurement

A more typical procurement approach is that being used on the Vega launching vehicle, which will be capable of putting 5,000 lb. into an earth orbit. Since this vehicle is based on the Atlas missile, NASA has granted Convair a $33.5 million initial contract calling for first flight tests in 1960 and delivery of eight vehicles in 1961. Instead of having Convair contract with General Electric for the second stage engine, as it would have under the system approach, NASA contracted directly with GE. NASA's Jet Propulsion Laboratory is developing a third stage liquid fuel engine, which eventually will be manufactured by some industrial company. JPL also has technical direction over the Vega project, and still other contractors will figure into development and fabrication of whatever payloads are used with Vega.

NASA is taking an almost completely decentralized approach to its contracting. Although research grants and some development contracts will be handled at headquarters, any contracts that support specific projects will be made at the laboratory where the project engineers are assigned. Project Mercury, for example, is being controlled by Robert Gilruth's Space Task Group from Langley Research Center in Virginia, and contracts for the capsule, support equipment, a tracking network and other phases of the program are being written there.

The purpose of this is to keep evaluation of proposals and technical supervision of contracts in the hands of those responsible for the project to as great a degree as possible.

All but the smallest contracts are reviewed by the small headquarters staff of 31. Brackett, an Army Air Corps and Air Force procurement specialist for 17 years before he joined NASA last January, believes this staff must be kept as small as possible and decentralization must be a major part of procurement philosophy if the flexibility needed for

How NASA Dollars Are Spent

	Fiscal 1960
Research and development	$333,070,000
Salaries and expenses	94,430,000
Construction and equipment	57,800,000
Total	$485,300,000

a rapid operation is to be continued.

The speed with which the agency's new role of procurement was taken in hand is illustrated by amount of the funds already committed. In the six months between the agency's beginning last Oct. 1 and the end of April, $140 million of the $250 million in Fiscal 1959 contract funds had been committed, and so had $105 million from the Fiscal 1960 budget. One reason for this initial speed was the fact that NASA took over some development projects that other agencies already had in progress, but even in these it generally had to write new contracting agreements.

Contracts for the 1.5-million lb. thrust Rocketdyne single chamber engine and the McDonnell capsule, which Brackett calls "two of our largest and most intricate procurements," were placed within three months after the procurement cycle began. Other procurement actions have been completed within 30 days, including negotiation, contract drafting, execution, review, approval and distribution.

For reasons of speed and uniformity and because it is doing business with contractors already in the defense industries, NASA is operating under the general principles and practices of the Armed Services Procurement Regulations. It also is included under the Federal Procurement Regulations, which apply to government agencies other than Defense Department and are quite similar to ASPRs, and NASA has requested to be allowed to follow the ASPRs whenever there is a conflict between the two sets of regulations.

Formal advertising for bids will be used whenever possible for NASA contracts, but the nature of research and development work calls for negotiated contracts in many cases because no definitive specifications can be written. Most negotiated contracts will be cost-plus-fixed-fee, and contractors are asked to submit the same types of cost breakdown and cost information usually requested by the military departments.

NASA has a cost analyst at headquarters but it will sometimes have the services furnish an analysis of costs—just as it has asked the cognizant service to administer its contracts in specific manufacturers' plants. Examples of this are Navy administration of the McDonnell capsule contract and Air Force administration of the Rocketdyne engine contract. Technical supervision remains with NASA personnel.

An important difference in NASA's contracting procedures is that in some cases, the government must take the title to inventions, unlike the practice under the ASPRs. NASA's patent regulations have been published in the Federal Register (May 5, 1959) and questions on these should be directed to the Assistant General Counsel for Patent Matters at NASA headquarters in Washington, D. C.

NASA Research & Development Programs

	FY1960 (estimates)
Aircraft, missile, and spacecraft research:	
Support of NASA plant	$16,670,000
Support of JPL plant	8,156,500
Research contracts	5,200,000
Scientific investigations in space:	
Sounding rockets	10,000,000
Scientific satellites	22,800,000
Lunar probes	7,140,000
Deep-space probes	6,803,500
Satellite applications investigations:	
Meteorology	10,800,000
Communications	4,700,000
Space operations technology:	
Manned space flight	70,000,000
Space rendezvous techniques	3,000,000
Space propulsion technology:	
Solid propellant rockets	3,000,000
High-energy propellant rockets	5,000,000
1,000,000-pound thrust single chamber engine	20,200,000
Nuclear rocket engines	8,000,000
Space engines	3,000,000
Auxiliary power units	3,000,000
Space systems technology:	
Advanced vehicle systems	1,500,000
Booster recovery systems	1,500,000
Orbiting space laboratories	2,000,000
Supporting activities: Tracking and data acquisition	11,500,000
Vehicle development:	
Scout	2,000,000
Delta	13,300,000
Vega	42,800,000
Centaur	41,000,000
Total	$333,070,000

NASA recently appointed Jacob M. Roey, former chief of procurement at Army's Watertown Arsenal, as its Small Business Adviser and Brackett said the agency intends to pursue "an affirmative small business program."

Brackett suggests that any firm seeking NASA contracts should obtain and fill out copies of the Bidder's Mailing List Application (government Standard Form 129) and file one with each laboratory and at headquarters. These forms are available at all NASA locations. These plus any brochures may be mailed. Brackett also suggests writing for copies of a booklet entitled "Selling to NASA."

Although NASA welcomes unsolicited technical proposals, Brackett points out that such a proposal "may possibly be accepted" after technical review, "but there is no certainty it will be. If it is accepted, a contract will be negotiated but funds are limited, and only projects that appear to have a direct and foreseeable bearing on the NASA program lead to procurement."

Although the advent of space flight has altered the missions of NASA's research centers, the following is a list of the centers, their general area of work, and their contracting officers:

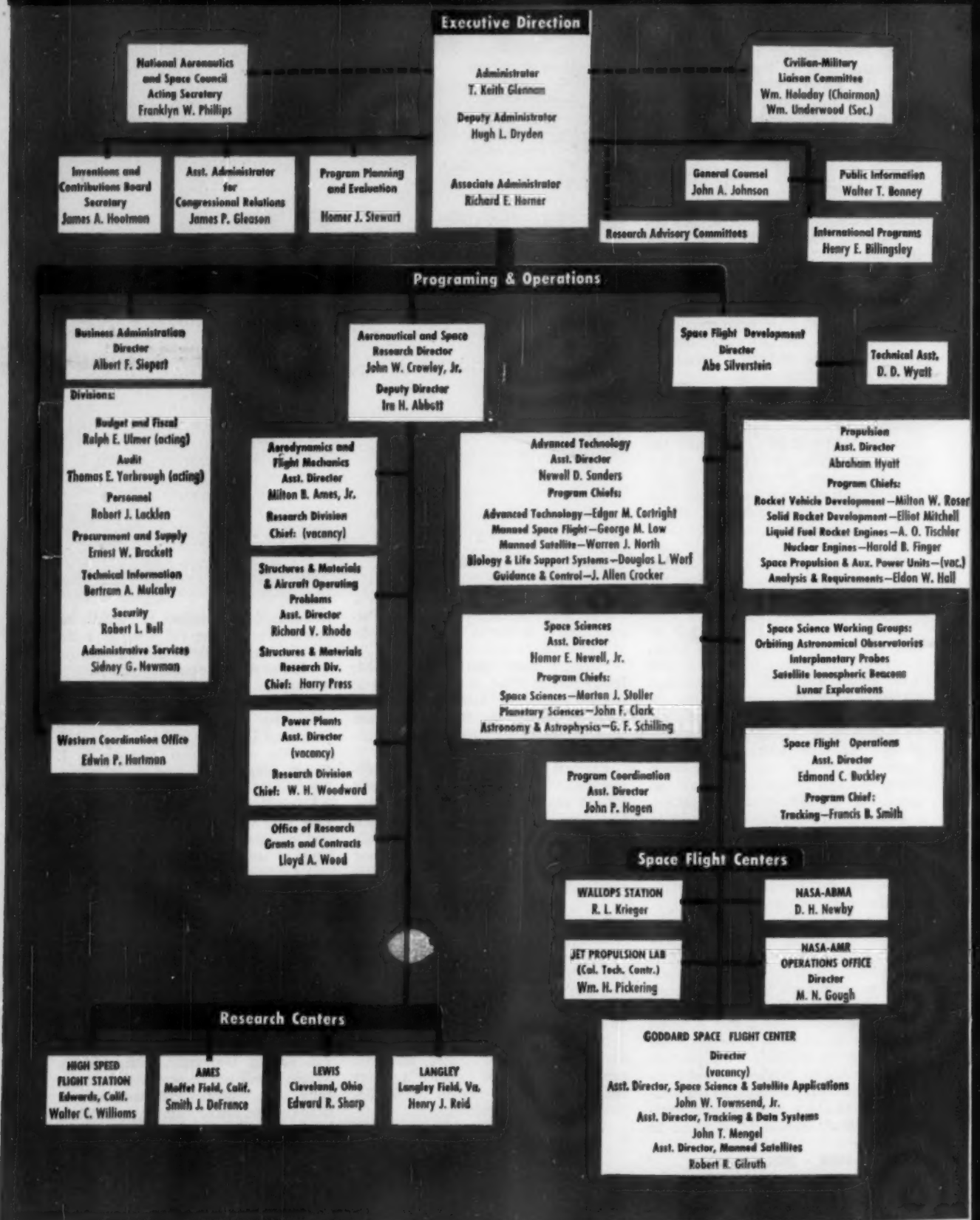
• **Langley Research Center,** Langley Field, Va. Aerodynamics. Procurement officer for supplies and equipment is Sherwood L. Butler and contracting officer for construction projects is J. Cabell Messick, chief of the engineering services division.

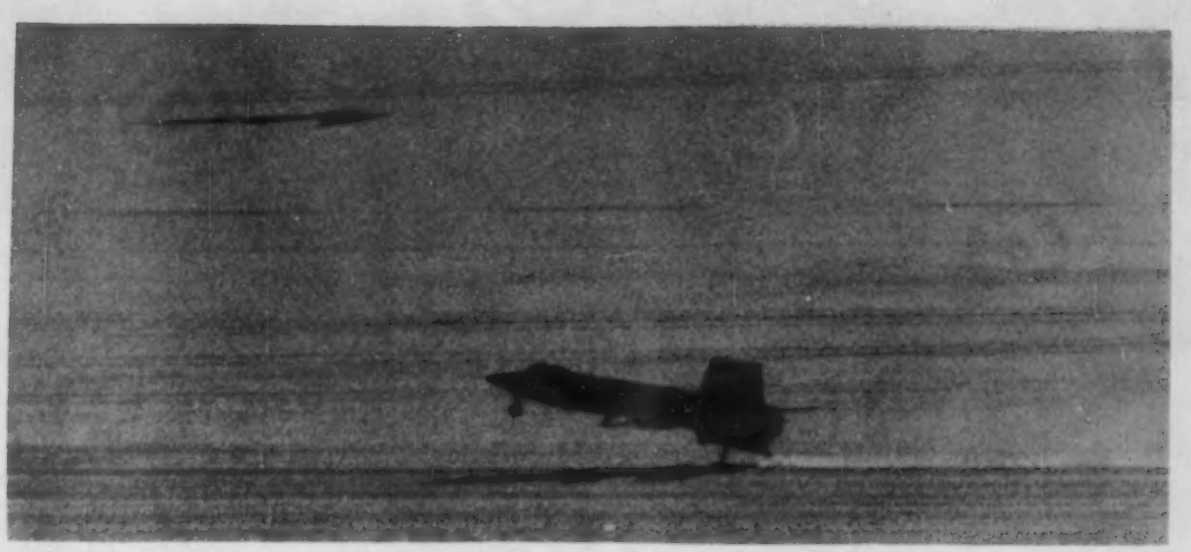
• **Lewis Research Center,** 21000 Brookpark Rd., Cleveland 35, Ohio. Fuels and engines. Procurement officer for supplies and equipment is E. C. Braig and contracting officer for construction is Charles A. Hermann, chief of technical services division.

• **Ames Research Center,** Moffet Field, Calif. High speed flight. Procurement officer is M. E. Bowling.

• **Goddard Space Flight Center.** This new facility, to be a research and development laboratory and command control center for satellite flight, will be built near Washington, D. C., and will have a Greenbelt, Md., address. While it will not be occupied for some time yet, procurement personnel at headquarters already are organized into headquarters and space center groups.

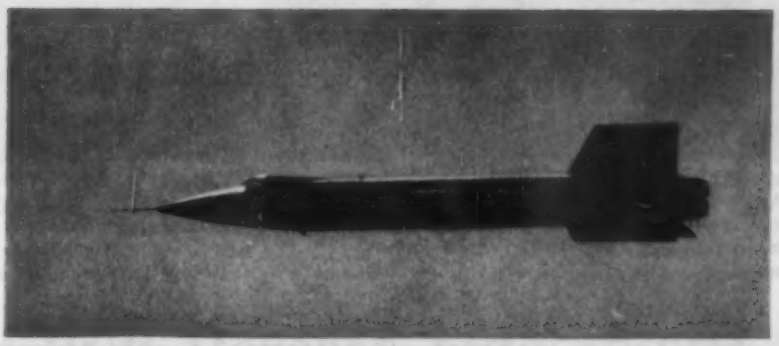
National Aeronautics and Space Administration

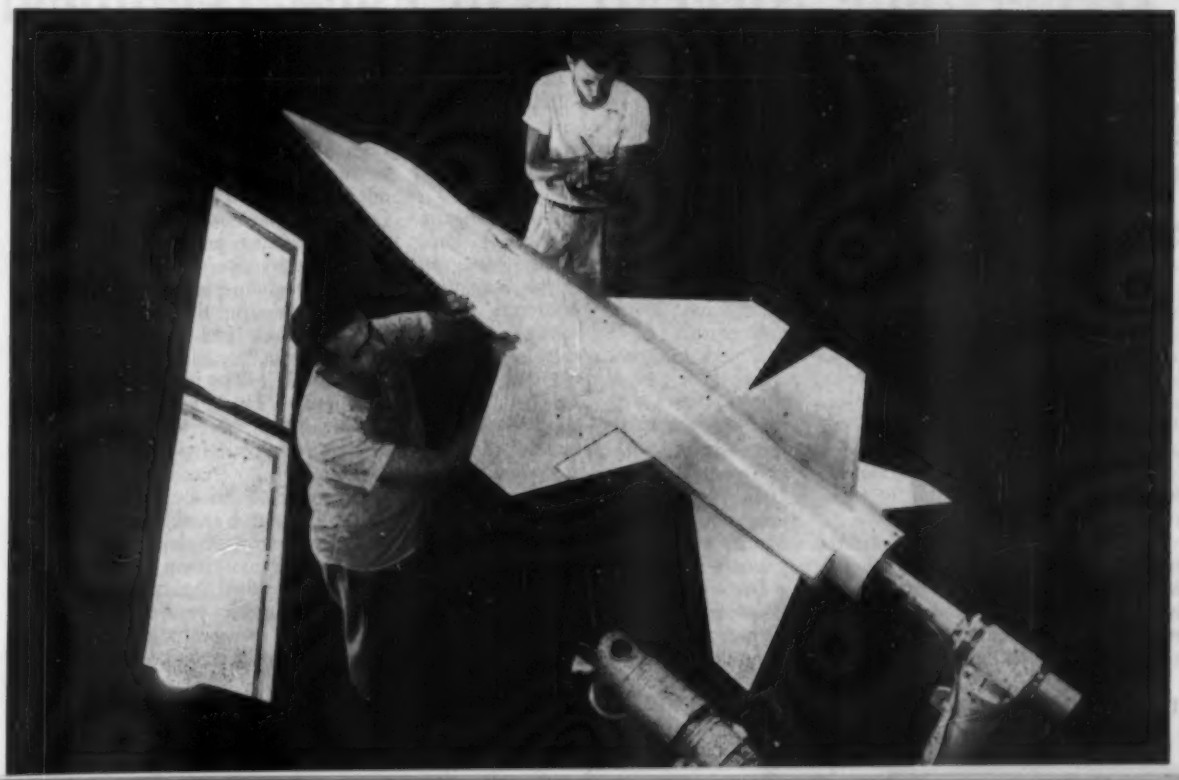


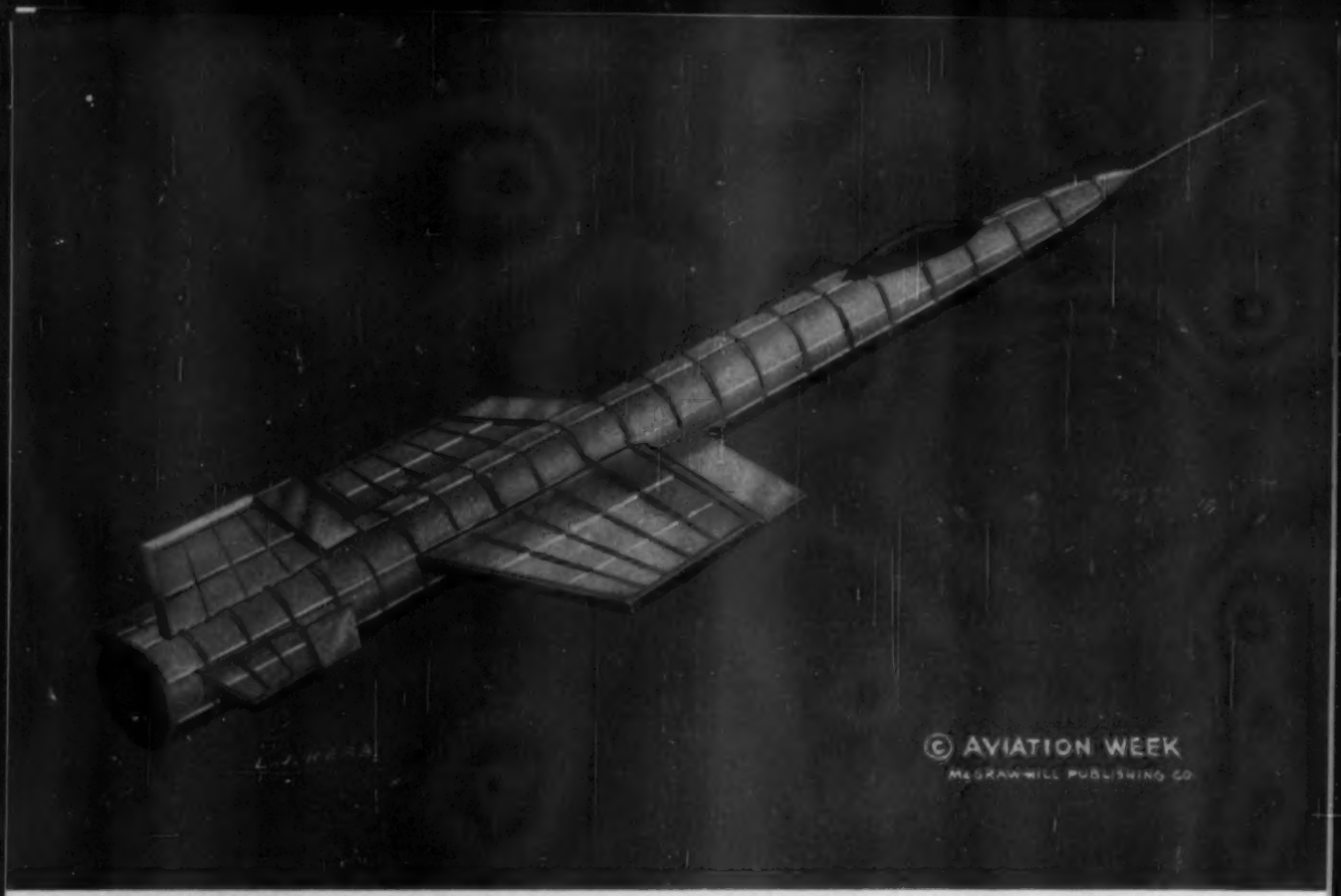


X-15 Progresses From Model Stage to Glide Flight

North American X-15 landing, above, and in flight (right) appears somewhat slenderized from earlier research configuration, below. Aircraft recently made first free flight (AW June 15, p. 29). Model is one used in National Aeronautics and Space Administration's Langley Research Center to study stability and control characteristics of use of differentially controlled horizontal tail for roll control at low speeds. Note shadow of Lockheed F-104 chase plane in landing photo.







HYPERSONIC aircraft suggested by leading theorists are shown. Above is an artist's conception of an aircraft with separated flow over most of its surface. A spike on the nose and "razor blade" extensions on the wings and tail create the separated flow and it is maintained by gas bled into the flow from the small waffles in the skin. Such design theoretically offers zero heat transfer to the aircraft and reduces skin friction drag to a small fraction of its normal value, thus relieving the two primary problems of hypersonic flight. Seymour Bogdonoff of Princeton University has proposed such a design method.

Hypersonic Aircraft Will Face Technical,

By J. S. Butz, Jr.

Washington—Hypersonic aircraft, now entering the development stage in the U. S., have two primary and interrelated problems—great technical disagreement over them and soaring costs.

It is, for example, almost impossible to find agreement among hypersonic research scientists as to the ideal configuration for a winged orbital aircraft. A somewhat greater measure of agreement can be found among engineers faced with the practical problems of planning hardware, such as in the Dyna-Soar I program, but the present conflicts of engineering opinion can still be compared in many ways to the confused aerodynamic design situation during World War I and shortly thereafter.

The cost of flying at many times the speed of sound under present concepts is illustrated by the Dyna-Soar I, which is scheduled to be the first truly hypersonic U. S. research aircraft. This boost-glide project is being managed jointly by the Air Force and the National Aeronautics and Space Administration and is a descendant of the North American X-15 and the X series of rocket-powered research aircraft.

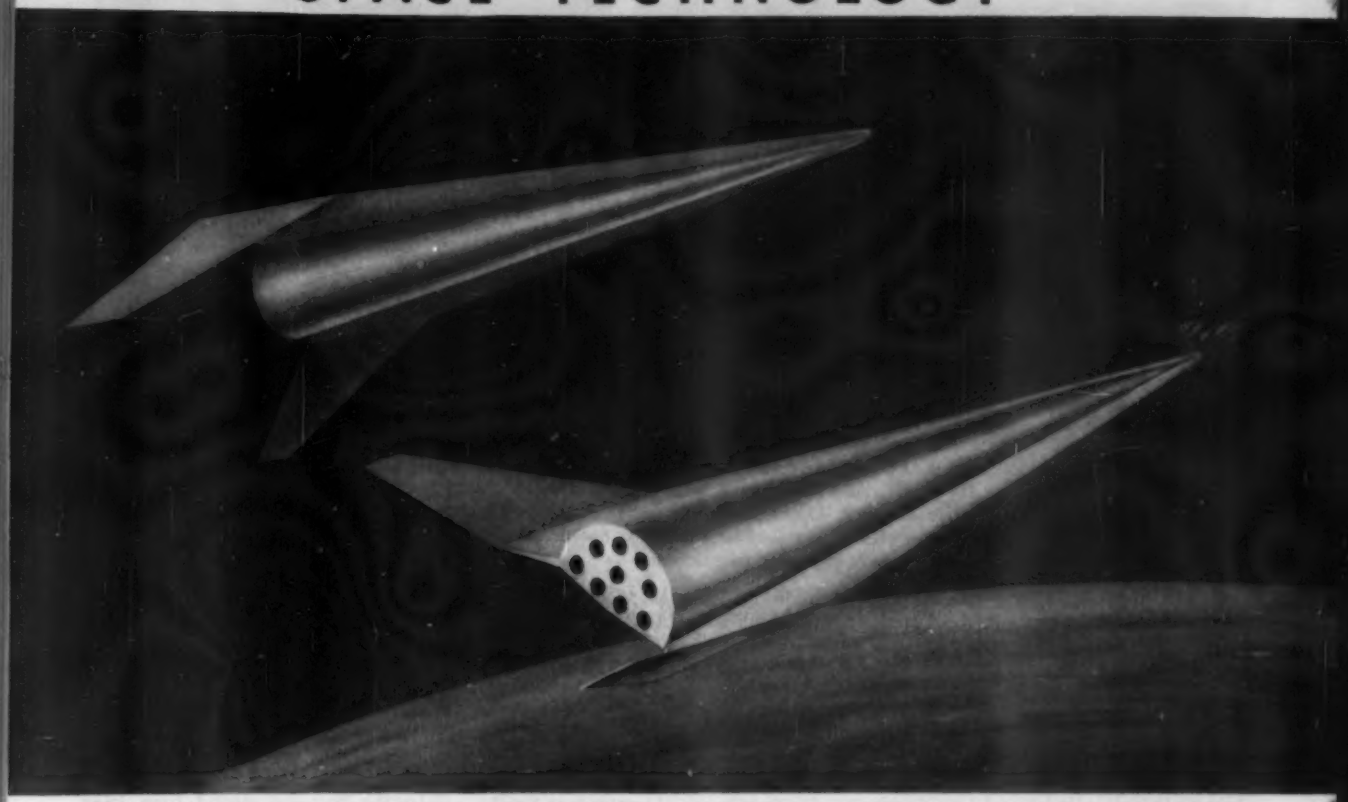
Dyno-Soar Program

The Dyna-Soar I flight test program is now planned around the traditional U. S. aeronautical research policy of slowly inching toward the maximum performance of research aircraft. Soundness of this policy of progressing into new performance regimes by small increments has been proven in the past since it permits many unexpected trouble areas to be identified and corrected before they become critical.

Two factors in the Dyna-Soar program indicate that it will be much longer and much more costly than any of the previous research aircraft programs. They are:

• **Large speed range** that the Dyna-Soar is intended to cover. Final goal of the Dyna-Soar program is orbital speed of around Mach 24. Actual flight experience with manned aircraft today extends only slightly above Mach 3 in the Bell X-2, and the X-15 is designed to little more than double it. Advancing from Mach 6 to 24 by small speed increments in a series of well thought out, well planned flights will take time. One decision that will speed the exploratory flight programs is to have three aircraft operating at one time. Such a program, planned for the X-15 and probably for the Dyna-Soar also, should reduce time lost for modifications, repairs, etc.

• **Dyna-Soar will be rocket boosted** from the ground which will raise the cost per flight well above that for a research aircraft dropped from a high-flying plane. The boosters in the Dynasoar program will be in the ICBM category and, unless some reliable method of recovering them is developed so that they can be used more than once, the cost of several hundred flights will be astronomical. Possible recovery techniques already are being studied under the sponsorship of the National Aeronautics



ARROW WINGED hypersonic aircraft above are suggestions of A. J. Eggers, Jr. of NASA and Wallace D. Hayes of Princeton University. The flat topped Eggers' configuration (middle), is designed to benefit from flow interference effects. Hayes aircraft (right) with the flat bottom is intended to keep skin friction drag low. Flight test information probably will be required to prove which design idea is best for any given speed and altitude situation. Slender high performance, high lift/drag ratio shapes of this type are best suited for flights half-way around the world down to transcontinental ranges. Blunt shapes are better for global ranges.

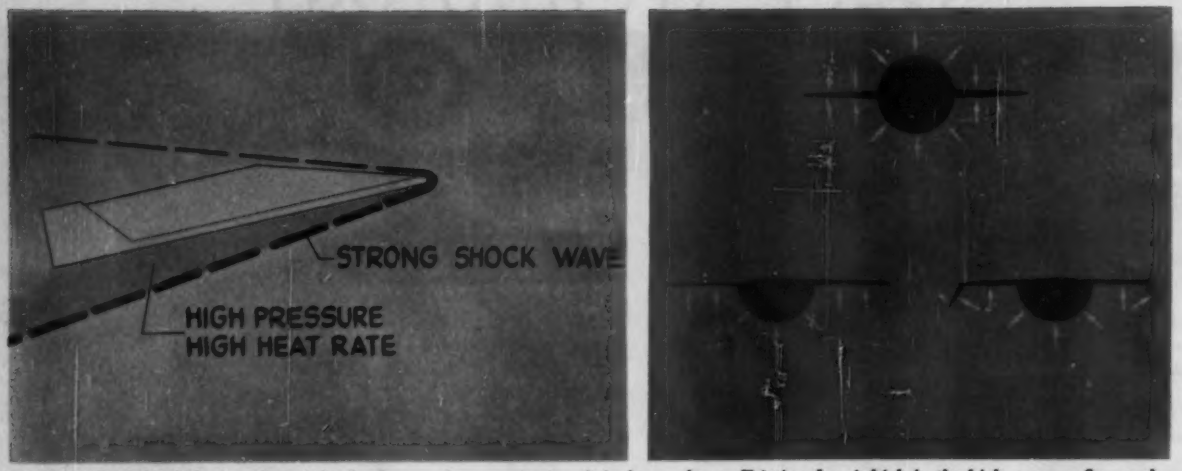
Cost Problems

and Space Administration (AW June 1, p. 30).

An additional source of great cost for the Dyna-Soar program is the materials needed for its construction. Steel, steel honeycomb, graphite and many new materials such as columbium and the refractory metals will be used on the aircraft, and they are expensive. All of these new materials are now in development, and experience is being accumulated on producing and forming them. They have no large-scale market, however, and their predicted costs remain very high for years. Air Force estimates are that each hand-built copy of the Dyna-Soar I will exceed $100 mililon.

These obvious high costs have brought a reconsideration of the entire Dyna-Soar program. There is considerable opinion both within the government and in industry that a very high cost program should be avoided until the last possible moment. This could be accomplished in part by sticking to research aircraft that are launched from other aircraft until Mach 10 or 12 is reached and

NEW MATERIALS and wing tanks could push X-15 speed to nearly Mach 9. Adding higher performance rocket engines could extend speed to about Mach 13. Launch from a Mach 3 bomber could then make Mach 17 a possibility. Extending performance of current research aircraft may be most economical method of reaching orbital speed with winged vehicles. Artist's conception above shows the X-15 wing range configuration which would allow the rocket to burn several seconds longer and increase the maximum speed.



REASONING behind the location of the fuselage on hypersonic aircraft is shown above. Friction drag is high in the high pressure flow under the wing (left). Fuselage above the wing reduces the wetted area in this region and keeps friction drag to a minimum. Front view of Eggers' interference flow configuration is at right. Upper portion is removed so that only lower fuselage will create pressure forces on wing. Turned down tips further increase downward momentum of air, raising lift. Speeds and altitudes at which interference effects cease to exist and friction drag becomes dominant are now open to disagreement.

leave the ground-launched versions for the higher speeds. A rebuilt X-15 using improved high temperature material and construction methods could exceed Mach 10 according to many engineers familiar with the project.

Fund Cut

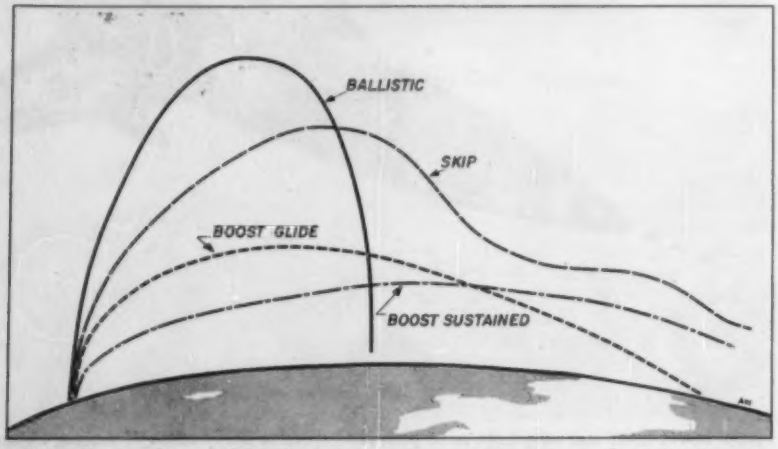
Air Force Secretary James H. Douglas told Congress that Fiscal 1960 funds for the Dyna-Soar program were cut by $136 million, indicating that intensive development would not begin next year. Douglas said the cut was based primarily upon state-of-the-art information. He also mentioned for the first time that another research aircraft might be built as an intermediate vehicle between the present version of the X-15 and the boost-glide Dyna-Soar I.

Present funding of the Dyna-Soar program is not high. The Air Force had $5 million specifically allocated for the industry competition for the Dyna-Soar I development contract. Two teams of contractors have competed during the past year for this development responsibility, and they have expended large sums of their own money.

The two teams of contractors for the complete boost glide system have been led by the Martin Co. and Boeing Airplane Co. as prime contractors. They were selected by the Air Force in June, 1958, as sources for the Dyna-Soar from among seven contractors who submitted preliminary designs in March of that year. The Martin team has consisted of Bell Aircraft Corp., the American Machine and Foundry Co., Bendix Aviation Corp., Goodyear Aircraft Corp. and the Minneapolis-Honeywell Regulator Co. Companies allied with Boeing have been Aerojet-General Corp., Chance Vought Aircraft, Inc., the Missile Division of North American Aviation, Inc., Thompson Ramo Wooldridge, General Electric and the Autonetics Division of North American Aviation.

In the four-year period from 1954 through 1957, the Air Force spent $3 million directly on the Dyna-Soar program; industry another $3.8 million. The National Advisory Committee for Aeronautics (now National Aeronautics and Space Administration) also had extensive research programs in progress involving hypersonic aircraft.

Selection of a configuration for Dyna-Soar I has been made with one primary factor in mind—stick to conventional ideas as much as possible in order to keep the number of unknowns to a minimum.

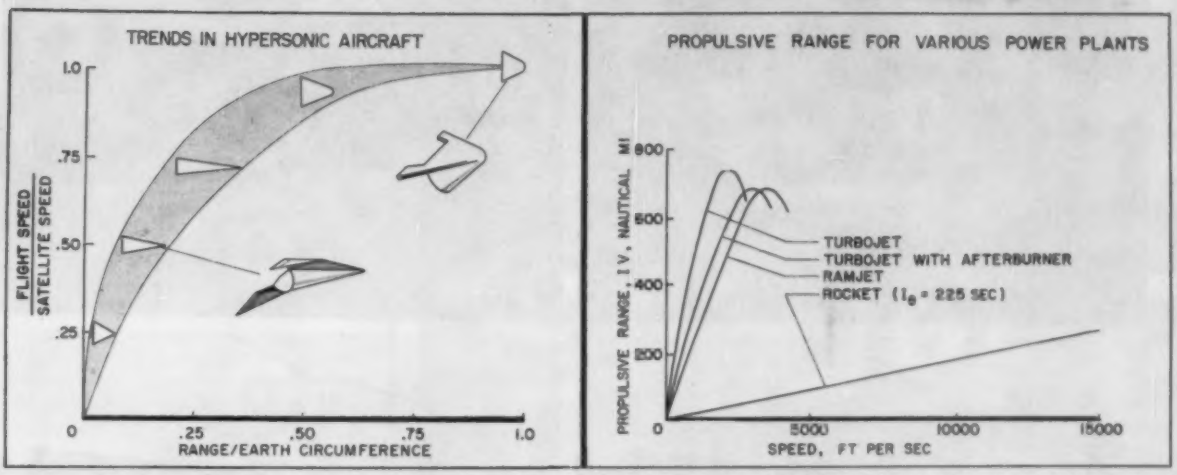


SKIP PATH is only one of four basic hypersonic trajectories not considered feasible today by NASA. Boost glide vehicle is accelerated to speed required for desired range and then it coasts. Boost-sustain is valuable when maximum vehicle temperatures are limited. Boost would be made to lower speed and would be sustained by small rocket. Vehicle gains altitude as fuel is expended. Combined trajectories are planned for most vehicles.

Dyna-Soar

Congressional testimony by the Air Force and NASA officials indicates that the Dyna-Soar I configuration will be somewhere between the extremely long and slender shape recommended by NASA for boost-glide aircraft with approximately transcontinental range and the blunt shape suited for orbital flight. (See top of opposite page for discussion and charts.) Dyna-Soar I also will have a rather low wing loading, and NASA predicts it will have better landing characteristics than the North American X-15.

First real goal of the Dyna-Soar I flight program will be the attainment of a speed range of between 12,000 and 15,000 mph., or about 60% of satellite velocity, at an altitude of between 150,000 and 200,000 ft. The

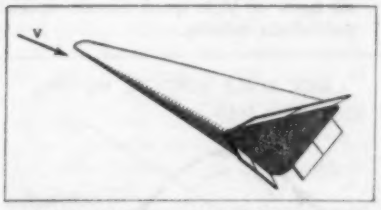


IDEAL VEHICLE shapes at various speeds are shown in NASA chart at left. Slim high lift/drag ratio shape could function as blunt body near global velocity by holding very high angle of attack. Low propulsive range and efficiency of rockets severely limits high speed vehicle performance. Combination powerplants such as the ram-rocket and the turbo-rocket have been advocated for years by several people including H. J. Allen of NASA to fill the area between the pure rocket and ramjet (right). Great development costs of new types of powerplants are prime reason it hasn't been done.

maximum heating during the re-entry from orbit in a winged vehicle will occur in this speed-altitude region. It is predicted that the most severe hypersonic design problems will have been solved if the aircraft can fly in this area. Some technical observers believe that so many unknowns are involved that Dyna-Soar I will require a major redesign when it reaches this maximum heating situation regardless of its original configuration.

In any event, the flight test data from Dyna-Soar I should make it possible to design boost-glide vehicles of greatly increased efficiency and utility. The data also should make it possible to realize the Air Force desire for the development of a manned orbital weapon system with wings and a maneuvering capability.

The current disagreement over the shape of this ultimate aircraft is due to the existing theoretical and experimental uncertainty regarding hypersonic flow. This uncertainty makes a large number of aircraft configurations appear to be efficient, depending upon the factors one tends to regard as unimportant.



MAXIMUM heating area is shifted from the wing leading edge to the ridge line at the bottom of this delta winged vehicle with large positive dihedral. This shape reduces skin temperature 50% over flat wing, according to preliminary NASA studies.

One promising sign is the steady theoretical progress being made and the outstanding individual contributions of some of the people working in government agencies, universities and industry. It has not been possible thus far to check this work exhaustively by experiment. The principal aeronautical research tool, small scale experimentation, is not as reliable and conclusive at hypersonic speeds as it is in the subsonic and supersonic regimes. Hypersonic wind tunnels, helium tunnels, shock tunnels and other very high speed facilities are not able to simulate flight conditions above Mach 10 for more than a very small fraction of a second. Also, each can give answers to only a portion of the problem.

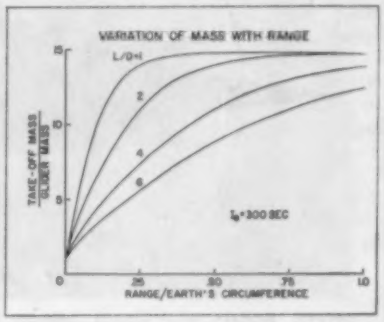
Today's picture of hypersonic flight based upon experimental experience has been pieced together from information from many types of facilities and numerous differences exist regarding the proper interpretation of this piecemeal data.

Design Problems

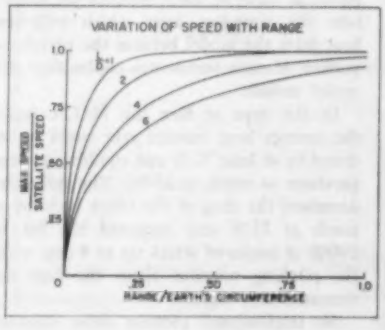
Most of the very difficult design problems connected with Dyna-Soar I and the other hypersonic vehicles to follow stem from one cause—heat. The enormous kinetic energy developed by these vehicles to achieve transcontinental range and more must be dissipated into the atmosphere as heat as they return to the ground. The aircraft will absorb only about 10% of this heat energy, but it is enough in most situations to vaporize an aircraft built for Mach 2.

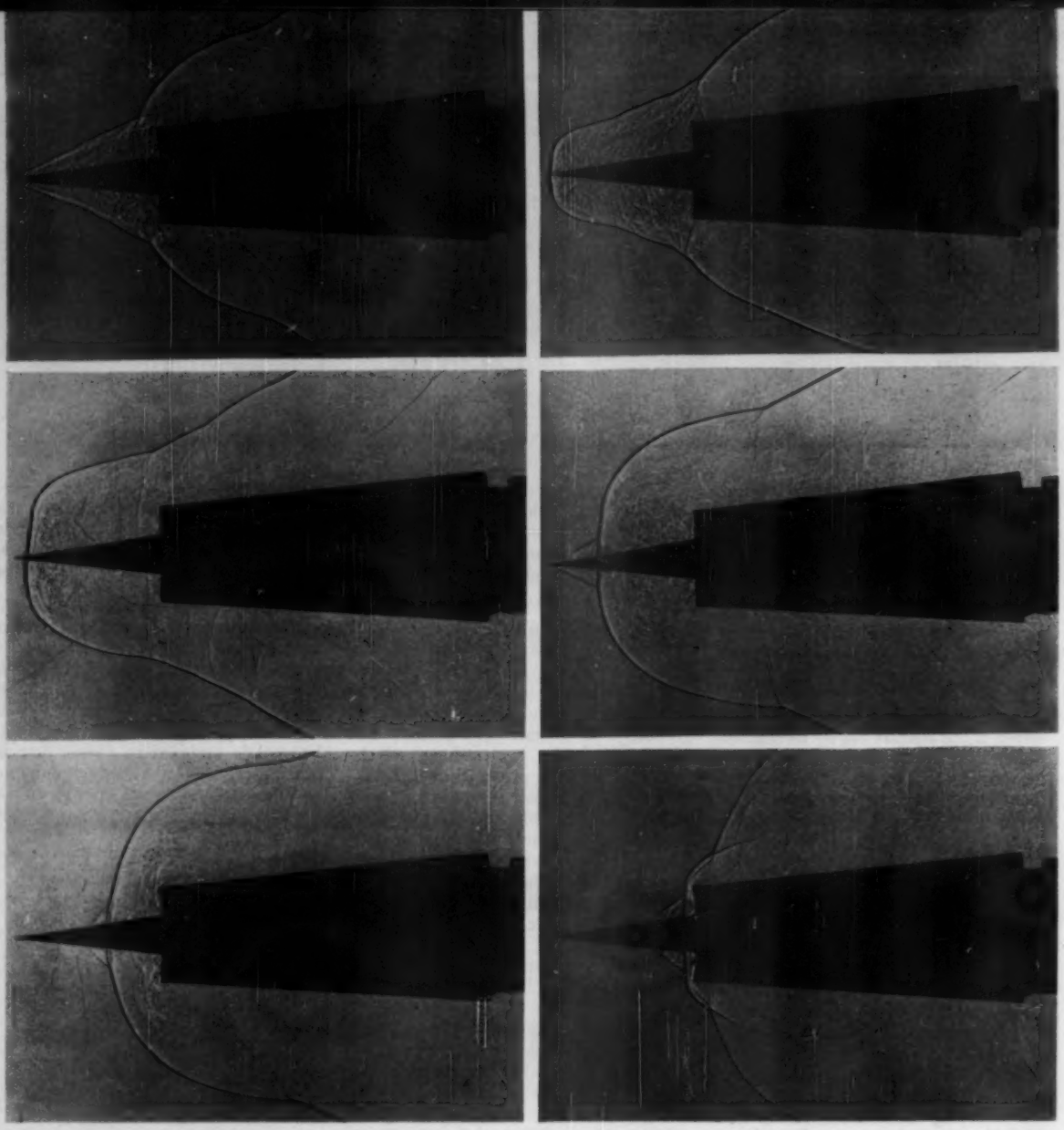
In the most basic view, three methods are available to either eliminate or reduce this primary problem of hypersonic heating. They are:

- Improving propulsion systems. If powerplant performance could be improved by a factor of 10 or more, it would be possible to eliminate the heating problem. Retrofiring engines rather than aerodynamic drag could be used at high altitudes to slow orbital boost-glide bombers to speeds that are not critical from a heating standpoint. In this ideal situation, power in the form of downward firing engines could



CURVES above and below illustrate the fact that high lift/drag ratios are beneficial through the hypersonic speed range but that their value decreases as global velocity is approached and centrifugal lift begins to support the aircraft.



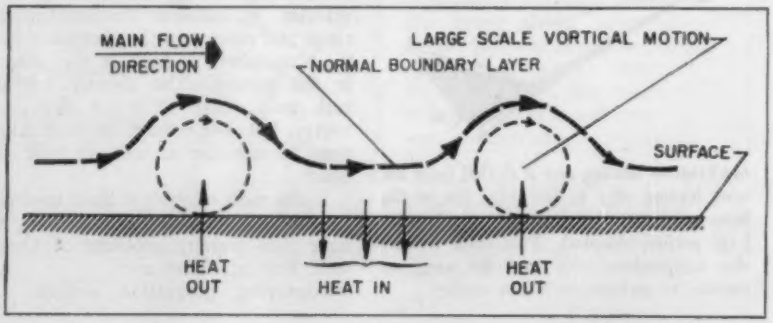


SPIKED BODIES have shown promise at supersonic as well as hypersonic speeds. Nose spikes were instrumental in cooling the surface of models at Mach 3 to 5 as far back as 1954 in tests by the old National Advisory Committee for Aeronautics. The spikes established an unsteady flow and injected as many as 2,600 vortices per second into the boundary layer which withdrew heat from the model because the peripheral portion of each vortex was cooler than the model surface.

In this type of flow the NACA found the average heat transfer rate could be reduced by at least 22% and equilibrium temperatures as much as 25%. The spike also decreased the drag of the blunt body by as much as 35% and increased the lift by 100% at angles of attack up to 4 deg. while the pitching moment about the base was increased only slightly.

Six shadowgraph pictures above illustrate the phenomena. Turbulent air builds up between the spike and the front of the model. A reverse flow begins on the spike forcing the shock wave to bulge out. The enlarged shock is forced rearward by the external air stream. The turbulent air behind the shock is then driven aft over the shoulder of the body forming a vortex. The sketch below is a schematic of the vortexes in the boundary layer.

The NACA's successor organization the National Aeronautics and Space Administration regards this type of cooling as a fertile field for added research in connection with all types of high speed aircraft especially for ballistic vehicles.



be used rather than wings to maintain altitude as speed was reduced and centrifugal lift could no longer support the vehicle in thin air.

• **Improving structures and materials.** If either knowledge of materials or building high temperature structures could be improved so that an aircraft could withstand 5,000 or 6,000F surface temperatures without a severe weight penalty, then both the high and low speed aerodynamic requirements of hypersonic vehicles could easily be satisfied.

• **Improving aerodynamic knowledge** so that the air flow around a vehicle traveling many thousands of miles per hour through the atmosphere would not heat its skin.

Useful Vehicles Foreseen

No one expects absolute scientific victories such as these described above for many decades. Yet it is certain that progress toward these three goals in the coming years will make it possible to operate hypersonic aircraft of great usefulness which could not be described as marginal in any respect.

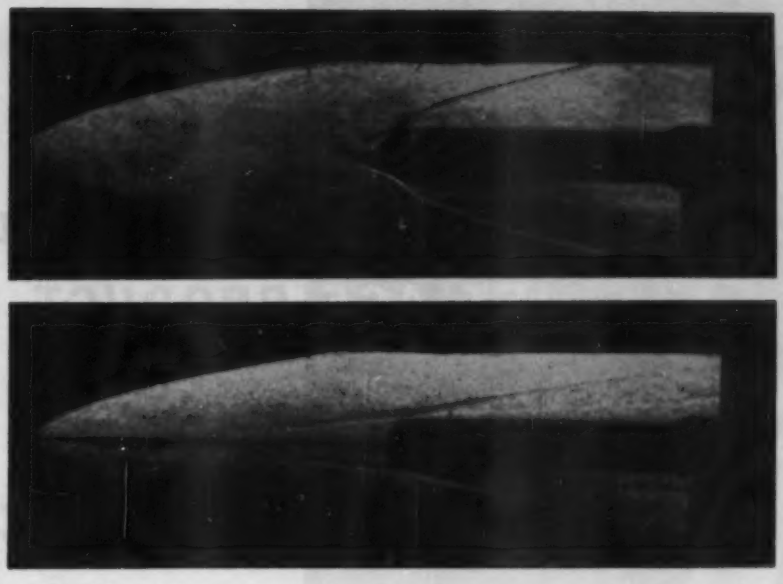
Hypersonic design requires the closest sort of coordination between aerodynamic, powerplant and structural specialists and any successful orbital aircraft will be a triumph for all three. However, there appears to be more hope for major progress among aerodynamicists. It seems certain today that no quantum jumps in rocket engine efficiencies are just around the corner, and the capacity of known materials apparently will be stretched to the limit to make hypersonic vehicles possible at all.

Reducing Heat Transfer

In contrast, there are some serious respected aerodynamicists who believe that it may be possible to reduce heat transfer at hypersonic speeds to zero for considerable periods. A wide variety of less complete but extremely hopeful aerodynamic solutions to hypersonic problems have been postulated. Larger and more advanced experimental facilities and actual flight test data will be needed to decide if these ideas are correct.

Reasoning behind each of these proposed configurations probably is best explained in terms of two factors which must be considered in the design of hypersonic vehicles that will achieve long range. One factor, structural heating, is a problem at low altitude. The other, skin friction drag, is a problem at high altitude.

In general terms, if a flight is made at low altitude where the air density is great, the surface of the vehicle becomes too hot. If the flight is made at high altitude, the air density and Reynold's number drop, and the skin friction

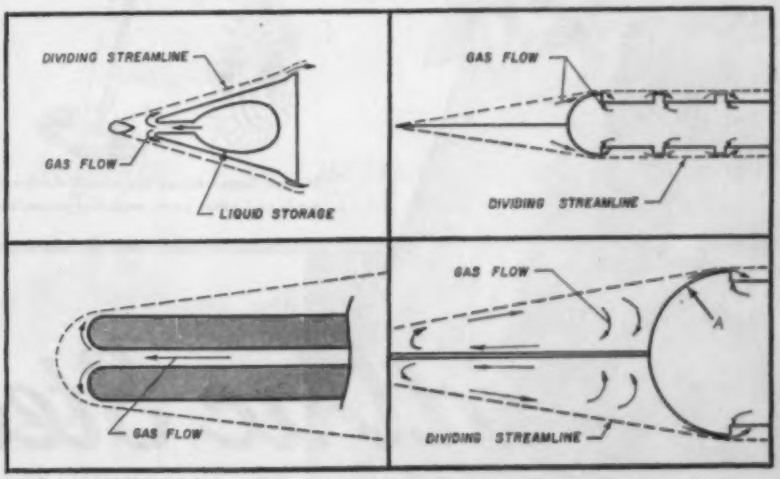


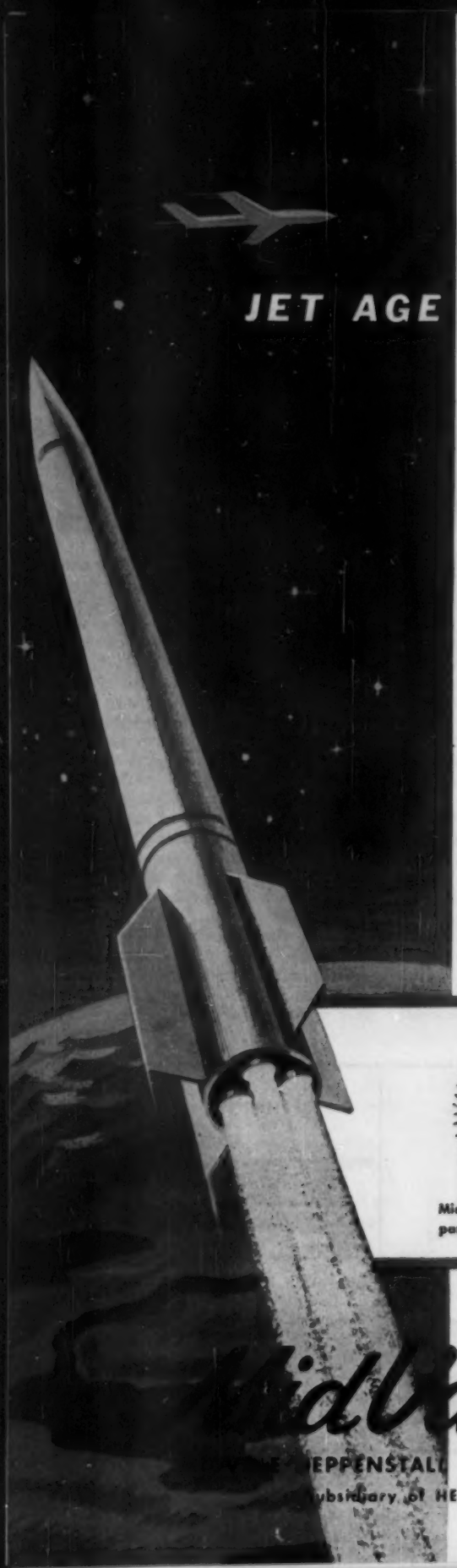
DELIBERATE FLOW SEPARATION has been used by Bogdonoff at Princeton to reduce the drag skin temperature, and pressures on a blunt leading edge. Schlieren photos above show a rounded leading edge body which normally has a zero lift/drag ratio with spikes of two different lengths attached to its nose. The small spike (top) raises the L/D to 1.0 and the long spike (bottom) boosts it to 7.0. This separated laminar flow over the forward section of the body lowers its equilibrium temperature to only a small fraction of that experienced when the flow is attached. If gas is injected into the space between the body and the separated laminar layer the heat transfer to the body can theoretically be reduced to zero.

Use of waffled rather than porous skin for this gas injection has been suggested by Dean Chapman of NASA and Bogdonoff. Chapman's theoretical nose cone cooled in this manner is in the upper left sketch at the bottom of the page. The gas entering the boundary layer from the waffle creates stabilizing pressures while injection from porous skin is destabilizing. Chapman calculated that this nose cone could travel 500 mi. at Mach 2 at 100,000 ft. altitude without any heating of its surface if one third of its volume was used to store liquid nitrogen needed for the gas injection.

Bogdonoff has proposed combining spiked bodies and razor bladed wings with waffled skin gas injection scheme to maintain separated laminar flow over an entire aircraft (schematic in upper right sketch) and keep skin temperatures down to Mach 2 levels. Lower left sketch is detail of possible spike design to keep it from burning away. Gas circulating between the spike or razor and body would prevent high temperature stagnation on vehicle (near A in lower right hand sketch).

Chapman and Bogdonoff believe that the great reduction possible in heat transfer and skin friction drag plus the low theoretical gas consumption make this general concept worthy of further study.





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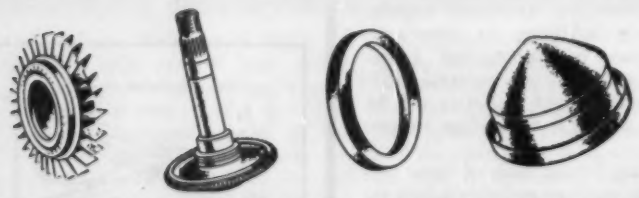

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goes up and lowers the vehicle's range.

Some of the hypersonic configurations considered today are:

• **All-wing configuration** or sharply swept arrow wing with all fuselage volume placed above the wing, suggested by Wallace D. Hayes, of Princeton University whose theoretical work has been prominently referenced by virtually all scientists working in the area of transonic, supersonic and hypersonic aerodynamics.

Dr. Hayes believes skin friction drag will be the primary consideration and recommends a vehicle with a minimum wetted area such as a flying wing. If a large fuselage is required, he believes it should be placed in the low pressure area above the wing because skin friction is higher in the high pressure region below the wing. Hayes does not believe that interference effects between a wing and a body can be used to raise the lift or decrease the drag of a vehicle above Mach 8. Over the principal portion of the speed range of an orbital aircraft, he believes that it would be wasteful to have any surfaces under the wing so that the maximum horizontal area could be exposed to high positive pressure and the lift would then be a maximum.

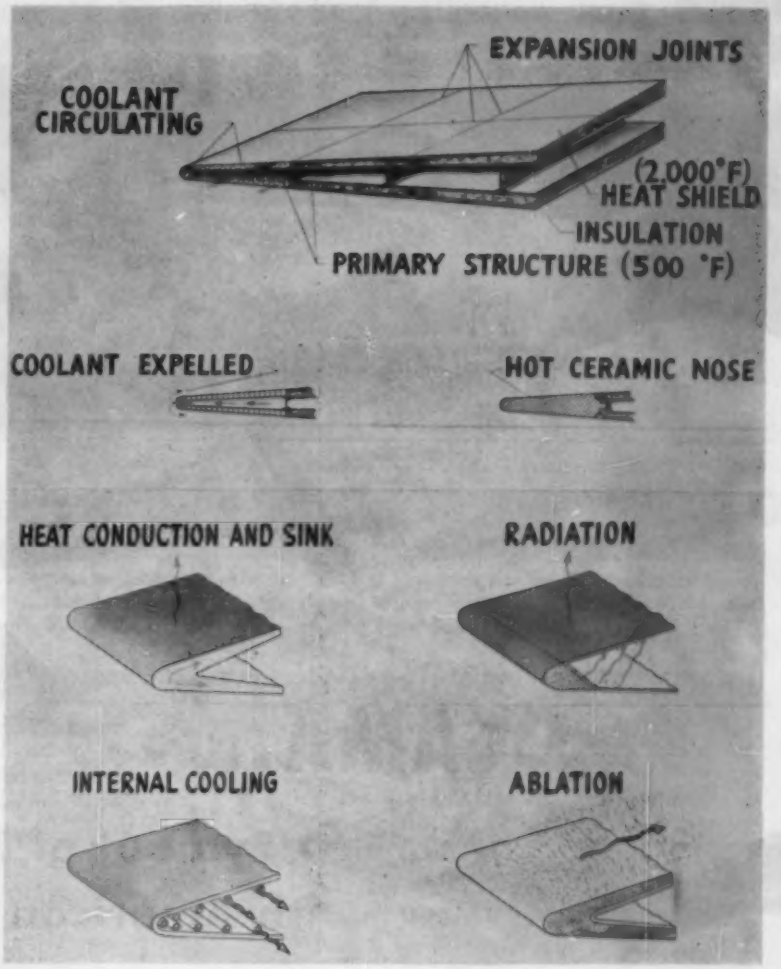
Hayes and Ronald F. Probstein, of Brown University, have just written one of the first extensive theoretical texts on hypersonic flow.

• **Flat-top vehicles** with highly swept wings (60 deg. plus) and fuselage placed underneath so that the wing and body flow fields interact to improve lift and/or decrease drag have been suggested by A. J. Eggers, Jr., of NASA. Similar vehicles which make use of interfering flow fields have been suggested by Antonio Ferri, Adolph Busemann and others. Major technical difference between the proponents of these vehicles and Hayes is that they believe that interference effects will be beneficial to a higher Mach number than does Hayes and that skin friction drag will not be a dominating design factor under quite the same conditions.

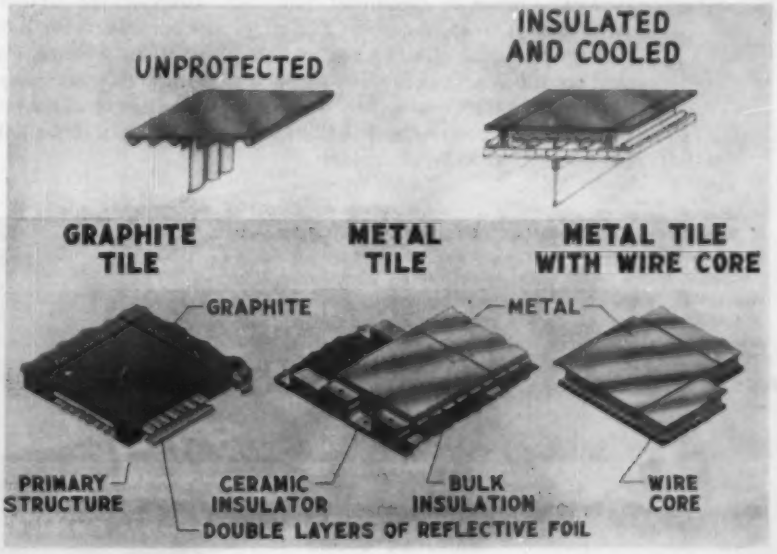
• **Straight wing aircraft** which has completely separated flow over a large portion of its surface may be possible in the opinion of Seymour Bogdonoff, of Princeton, a pioneer in the use of the helium tunnels, a major tool of hypersonic research.

Experimental data from the helium tunnel has led Prof. Bogdonoff to believe that the flow around a body above Mach 10 may be completely laminar. Separated laminar flow results in a great reduction in both skin friction drag and heat transfer. If Bogdonoff's laboratory work proves correct, it will be one of those rare occasions when two major flight problems are relieved simultaneously by the same mechanism.

This type of flow is maintained by



CONSTRUCTION IDEAS for hypersonic aircraft include those shown here in NASA sketches. Sections below would be used on fuselage and wing. Common characteristic of all high temperature ideas is that the skin will be lightly stressed as it was on canvas covered airplanes and in contrast to modern supersonic aircraft.



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gas injection from a waffle skin (see p. 161). Bogdonoff's experiments have indicated that it is possible with this type of mass transfer cooling to reduce the heat transfer from the separated laminar flow to the aircraft to zero with only a small consumption of cooling gas.

Purely theoretical work in this area has been pursued by Dean Chapman, of NASA, who played a key role in the development of blunt base airfoils. Dr. Chapman's work with transpiration cooling, using a waffle skin rather than gas injection from a smooth surface, agrees substantially with Bogdonoff's.

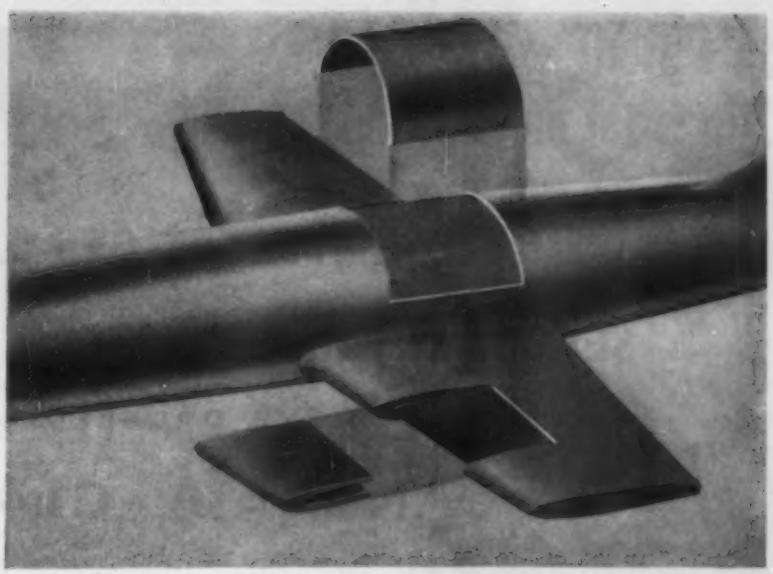
• **Conventional aircraft** configuration similar in appearance to either the X-15 or Convair F-102 which would be covered with ablating material. The success of nose cones with lightweight ablation heat shields has given considerable impetus to this idea among both industry and government engineers. Simplicity of the device which eliminates complex cooling systems and greatly reduces thermal problems in the structure has brought ablation into favor with many technical people working with the Dyna-Soar problem. They believe it offers the quickest way to get an aircraft into the higl. hypersonic speed region even though it probably will require a new outer coating after every flight.

Military Objective

The Dyna-Soar I flight test program has another major objective besides producing hypersonic flight test data. The second objective is to bring some agreement among military officers, scientists, engineers and university presidents as to just what missions the hypersonic aircraft should be used for and what its over-all capabilities should be.

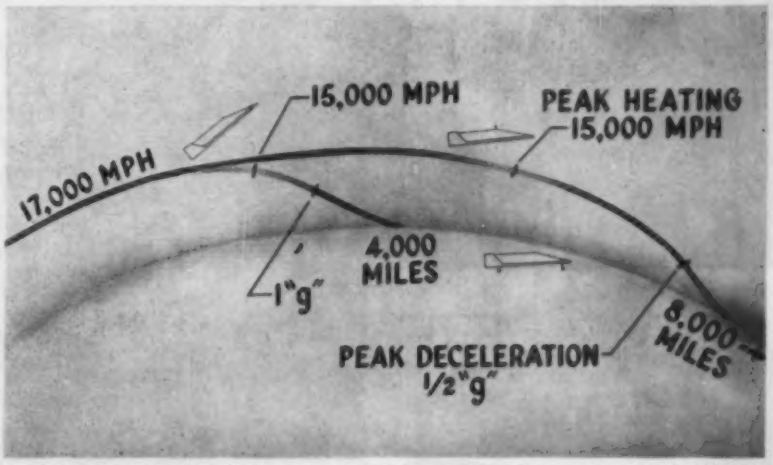
Probably no aerial weapon since the Wright biplane has come into the military planning picture with as little understanding and agreement about its optimum mode of operation, its attack and reconnaissance potential and its limitations. Public statements by responsible people have ranged from, "it would be impossible to drop a bomb from an orbital vehicle" and "it would be extremely easy to shoot down an orbital bomber" to "the Dyna-Soar weapon system will be able to police the world." Major questions connected with the flight and military operation of Dyna-Soar type vehicle include:

• **Landing.** Decision as to how the hypersonic aircraft will return to earth is closely connected with the whole design philosophy of the vehicle. If it is short and stubby and not intended for extensive maneuvering in the atmosphere, it will have to be recovered by parachute. If the vehicle is to have any chance of being useful in the atmosphere, most engineers feel it will have to be approached in the classical



ABLATING sections fastened to the surface of hypersonic aircraft offer the lightest means of handling high heat loads, in the opinion of many engineers. Sections would be easily removable to allow quick replacement after every flight.

LOCATION of high temperature areas on a high/lift drag ratio vehicle are shown above (light areas). Following universal hypersonic design thought, the wing leading edges are rounded to reduce local heating. Most designers then recommend sweeping the wings sharply to reduce the drag of the rounded edges.



TWO re-entry paths feasible for winged aircraft are pictured here with the deceleration each will impose.

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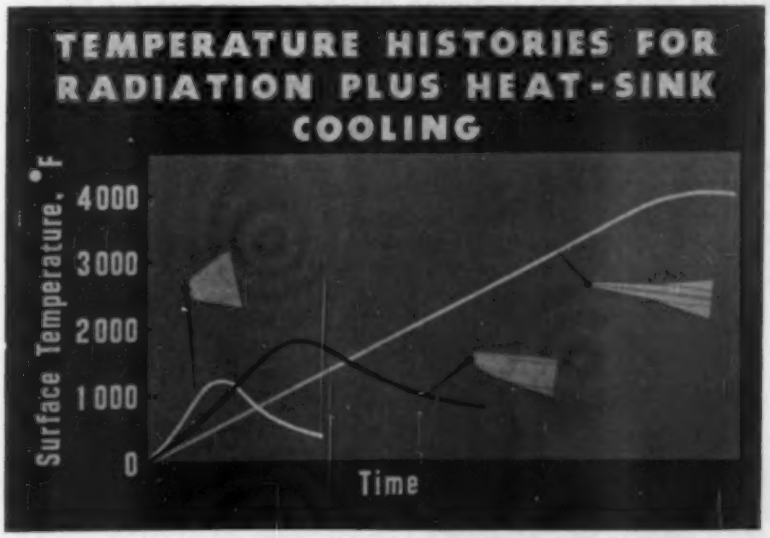
manner: i. e., it will have to develop maximum lift at a minimum cost in drag during most of its flight. Such a vehicle will, of necessity, be long and slender. It probably will have poorer landing characteristics than the X-15 regardless of whether it has highly swept or straight wings and whether it uses boundary layer control and variable geometry.

Some engineers and pilots do not consider this to be a blessing or an achievement because the X-15 during a landing has a vertical descent rate of nearly 200 mph. just before its flare which must be initiated hundreds of feet in the air. NASA officials have described such landings as controlled crashes while others regard them as relatively uncontrolled crashes. Either way, considerable thought is being given to the parachute recovery of high-performance hypersonic vehicles.

• **Maneuvering.** Navigation of a hypersonic vehicle to land on an airfield the size of the dry lake at Edwards AFB, Calif., to avoid enemy counteraction or to attack a specific target on the ground is a major task for two reasons.

First, the exact course of the hypersonic aircraft must be determined shortly after takeoff if there is to be a chance of making navigational corrections. The navigation system probably will be contained principally in the aircraft because of the difficulty of transmitting ground tracking information to a vehicle traveling close to



HIGHER re-entry temperatures and lower heating rates of the slender high performance aircraft are shown above in comparison with the blunt drag bodies.

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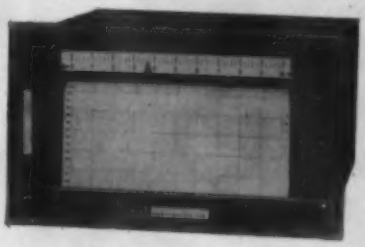

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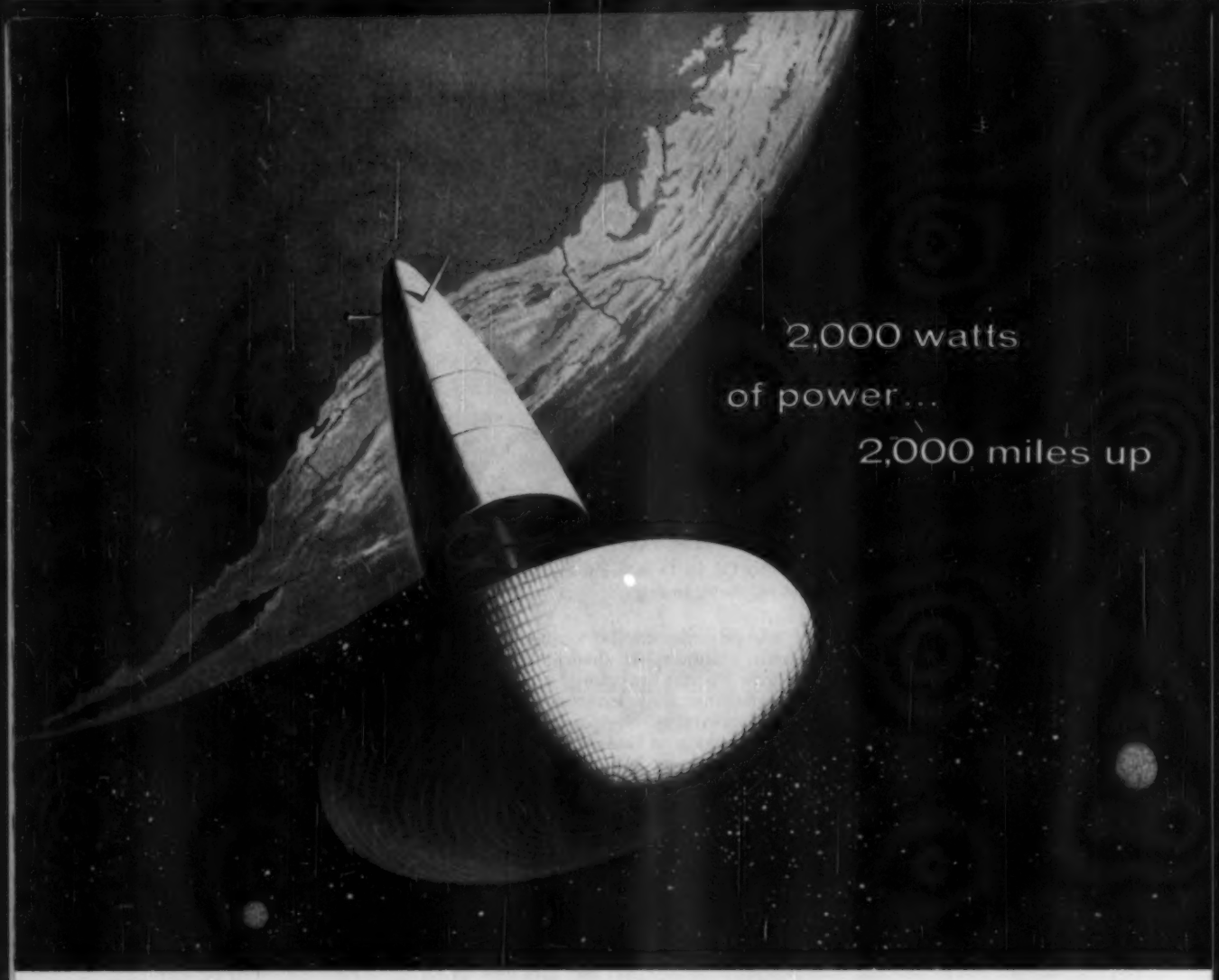

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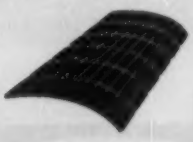

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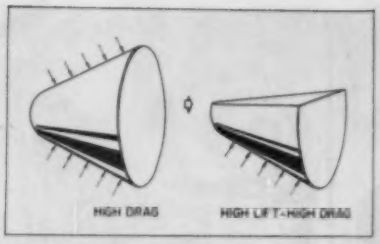

HIGH LIFT-HIGH DRAG shapes have been suggested by Eggers for sub-orbital vehicles to take advantage of the lower total heating of the high drag shape and reduced heating rates of the high lift body.

orbital speed at less than 40-mi. altitude. Inertial units and computers required by such systems are believed to be available in current technology if not in hardware.

Second, even the slightest change in course requires an enormous energy expenditure at hypersonic speeds. Adolph Busemann determined during the 1940s that at .707 of satellite velocity, a 360 deg. turn requires as much energy as one orbit. Hypersonic aircraft will be restricted to slight turns, climbs and gentle descents to conserve energy and achieve maximum range as well as to keep from overstressing the structure.

A very rapid and accurate correlation will have to be made continuously between the amount of kinetic and potential energy remaining and the amount required to reach specific areas. The navigation system will have to determine when to make maneuvers so that the proper amount of energy will be consumed and the aircraft will arrive over the landing area at the proper speed.

• **Pilot's value.** Apparently most engineers and Air Force officers believe that a manned hypersonic glider will be superior to the unmanned version. However, the use which can be made of the pilot's skill and judgment is understood only in a general way for the hypersonic speed range. Many automatic systems will be mandatory in these aircraft.

Air Force testimony before Congress indicates that Dyna-Soar I may be unmanned. It is possible then that flight testing in critical flight regimes may be first undertaken by an unmanned aircraft following the pattern to be set by the Mercury project.

• **Attack.** Engaging ground or airborne targets with weapons launched from a hypersonic aircraft is believed to be feasible by most engineers, but the extent of this capability is far from established.

• **Reconnaissance.** Type, quality and quantity of reconnaissance data which can be collected by hypersonic aircraft is another question that cannot be clearly answered at present.

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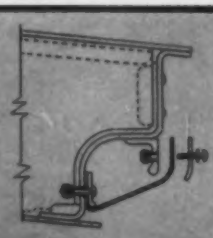

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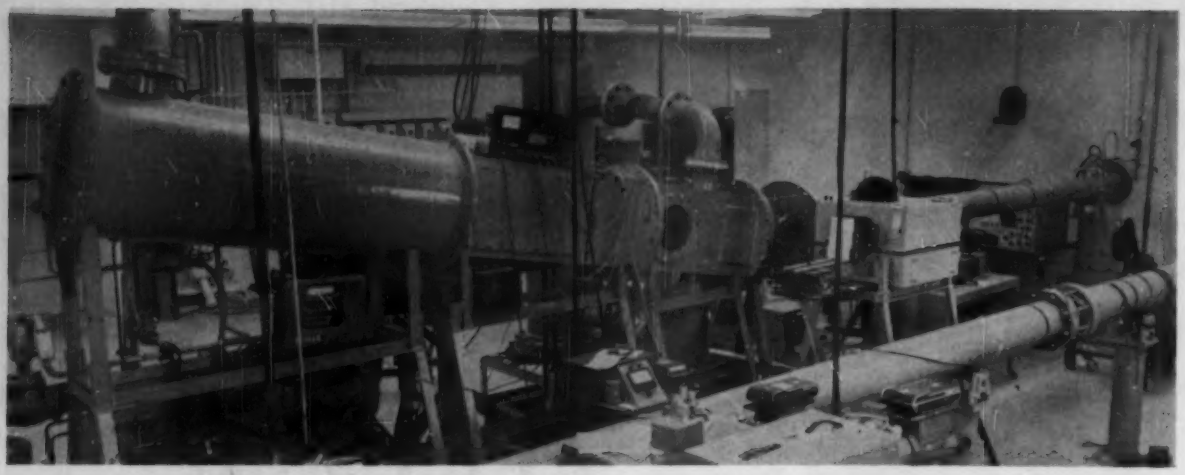
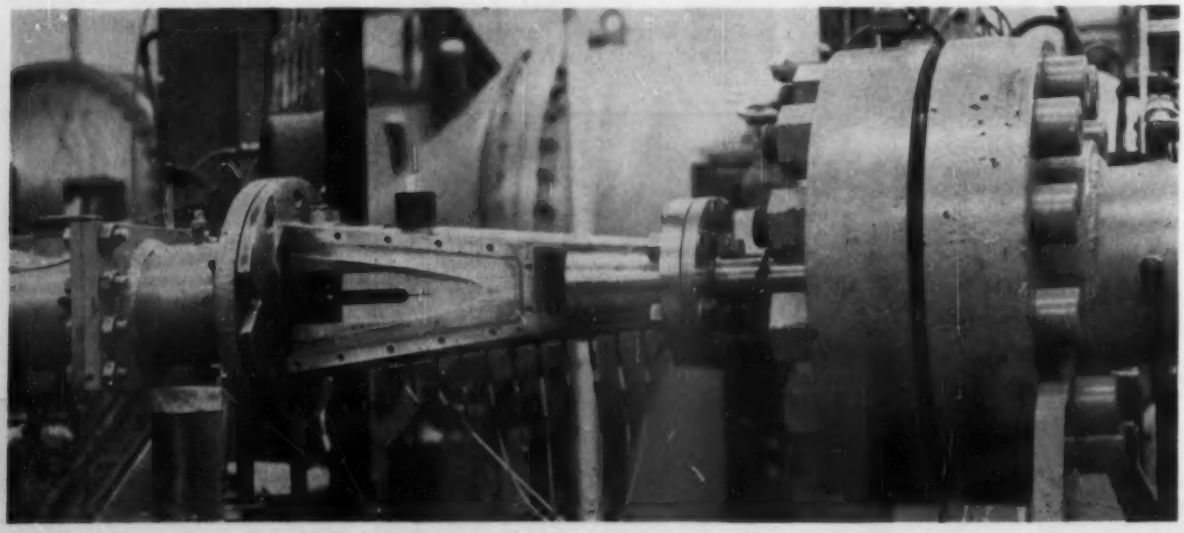


Tunnel Studies Probe Unknown Hypersonic Areas

Experimental study of hypersonic phenomena is handicapped by the fact that no single facility is able to duplicate all the necessary flow conditions while allowing precise measurements to be made at close range. Two of the principal research tools are shown here: the "hot" shock tunnel using air is above and the "cold" helium tunnel is below. The helium tunnel achieves a very high Mach number to 20 and above but does not produce the proper "real gas" effects. These effects are the primary difference between hypersonic and the slower speed flows. They arise because the air no longer acts as a perfect gas. As the temperature rises the gas molecules are first excited in their vibrational modes, then dissociate into separate atoms and finally the atoms are ionized. These processes absorb considerable energy which is released if the processes are reversed as the flow moves over a vehicle. It is not possible today to predict exactly when the air molecules will absorb or release this energy or the effect it will have on a hypersonic vehicle's surface pressures and temperatures. The "hot" tunnel provides the necessary "real-gas" effects but usually at Mach numbers less than 10 and only for a small fraction of a second. Rocket propelled models, shock tubes, tunnels with pebble heaters and the other high speed research facilities all have limitations similar to those of the helium and air tunnels. Steady progress is being made, however, especially in instrumentation techniques. The understanding of hypersonic flight which has been pieced together using the data from these facilities is hazy in many respects. It is not clear at present exactly what flow variables are important at hypersonic speeds. Mach number is no longer a key element in describing the flow. Gamma, the ratio of specific heats of the air or gas used in the test work, is very important. Gamma has been described as a measure of the sponginess of a gas. Helium has a gamma, its molecule is a single atom and its motion can be described completely by its translational movements. Air, on the other hand, is a diatomic molecule shaped like a dumbell with a low gamma. It can not only have translational motion along three axes but it has a large moment of inertia about two of them so that when it rotates it absorbs energy. A change in gamma alters the shock wave system around a body. In helium at Mach 20 the shock wave shape is like Mach 10 or less in air. At high Mach numbers in air the shock wave bends back almost to the body surface and reaches a limiting condition. Shock tunnel above is located at Cornell Aeronautical Laboratory. It uses flow reflections to raise testing times to four or five milliseconds which is well above the average. A group headed by Abraham Hertzberg and Frank Moore operates this tunnel. The Princeton helium tunnel below is operated by a pioneer group in the field under Seymour Bogdonoff.



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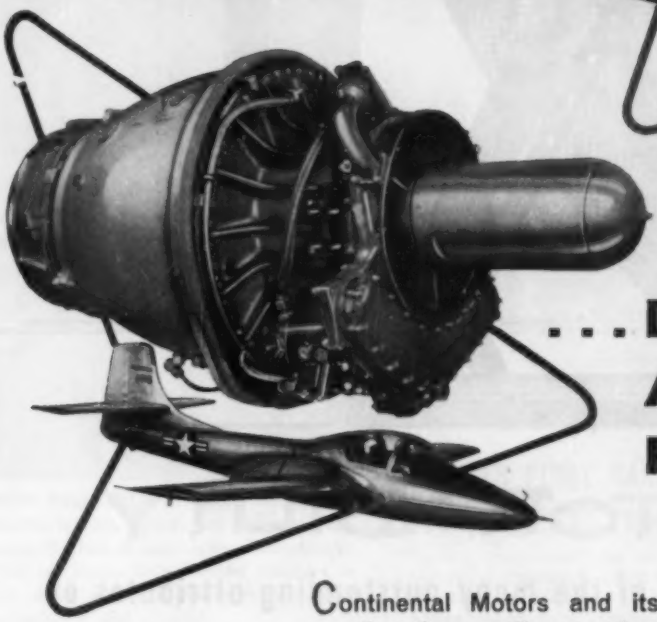

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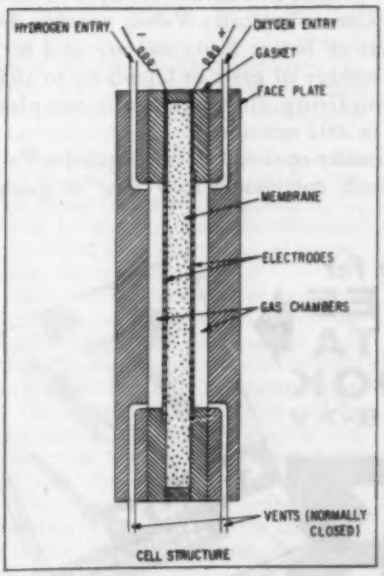
Fuel Cell May Have Satellite Application

Schenectady, N. Y.—Development of a hydrogen-oxygen fuel cell with over 60% thermal efficiency by the General Electric Research Laboratory here could add new interest to consideration of chemical auxiliary power systems for satellite applications.

Like other chemical systems for generating electricity, the fuel cell offers the advantages of compactness, freedom

NEW FUEL CELL developed by General Electric features a plastic ion exchange membrane in place of usual aqueous electrolyte. Unit has shown 60% thermal efficiency in the production of electricity from reaction of hydrogen and oxygen.



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CIRCLE NO. 173 READER SERVICE CARD 173

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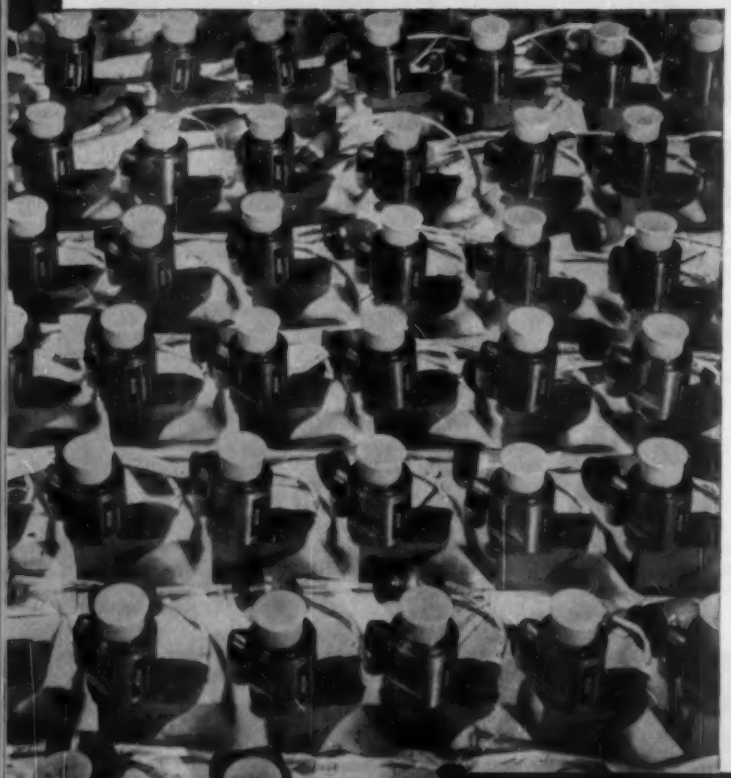

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Unretouched photographs above show a few of the thousands of Conax Explosive Valves that have been made to highest aircraft standards and put into operation on missiles.

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from moving parts and silent operation. On the other hand, it produces low-voltage direct current and would require the addition of an alternator to produce the alternating current generally required by satellite equipment.

The new fuel cell developed by General Electric is a round plastic disk three inches in diameter and one-half inch thick. Inside, a plastic membrane divides the cell into two chambers. In each chamber there is an electrode set against the side of the dividing membrane.

Unlike the more conventional hydrox fuel cells which use aqueous electrolytes, the new General Electric unit employs an ion exchange membrane to transfer the charged particles. This solid electrolyte, the company says, has the advantage of keeping the electrolytically conducting ions locked in and preventing them from being leached from the cell.

Hydrogen is fed into one chamber of the cell and oxygen into the other. At its electrode, the neutral hydrogen atom loses one electron and becomes a positively charged hydrogen ion. The electron flows through an external circuit to the other electrode, therein generating the desired electric current. Meanwhile, the positively charged hydrogen ion is transferred through the membrane to the other chamber where it reacts with the oxygen present to form water.

Extrapolating data from the operation of a number of their new units, General Electric researchers have calculated cell power densities of from one to two kilowatts per cubic foot.

Mercury Booster Recovery Studied

El Segundo, Calif.—Recovery system for Jupiter-C boosters to be used late this year in Project Mercury tests is being designed by Space Recovery Systems, Inc., a new company organized here for work in the field of high-altitude recovery systems.

The unit for the Jupiter-C, a modified Redstone missile, will utilize a system of parachutes and electronic equipment to save the boosters. Recovery system cost approximates 1% of booster value, the company says.

In addition, while working to design and produce hardware to meet the Jupiter-C flight test deadline, the company also is conducting feasibility studies for recovery of larger boosters such as the Jupiter and Atlas which will be used later in the Mercury program and other space systems, and will use flight test data derived from the Jupiter-C.

Theodore Knacke, vice president-engineering of the firm, said the company is looking toward something other than

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parachutes for the best recovery systems which would work at high altitudes, in the order of 250,000 ft. and above, where there is not enough air to deploy a parachute. Something akin to inflatable spheres and paraflaps are envisioned for this, Knacke said.

The system would employ lift to keep the vehicle at a high enough altitude during deceleration to minimize aerodynamic heating, while using a maximum drag device to accomplish the desired deceleration itself. A re-entry slope of two to four degrees would be desirable to reduce the heat transfer during re-entry, Knacke said.

Three cardinal problems of recovery are heating, deceleration and accuracy, and to solve the accuracy problem, it is not impossible that a guidance system of some sort would be used in the final parachute stage of the recovery system.

Space Recovery Systems, Inc., is a combined operation of Columbia Broadcasting System's CBS Laboratories Division and the M. Steinthal and Co. subsidiary, Aeronautical Equipment Research Corp. The new company took over the complete operation of Aeronautical Equipment Research here, and through the combination makes available the facilities of the CBS electronics unit and the parachute facilities of M. Steinthal of New York.

Hound Dog Launched Twice Over Atlantic

Los Angeles—North American GAM-77 Hound Dog air-to-surface missile has been launched twice over the Atlantic Missile Range off Florida.

Both flights were termed "successful" by North American Aviation's Missile Division. Two-for-two score was run up in tests staged out of Eglin AFB and launched over the Atlantic Missile Range from Cape Canaveral. The missile is designed to be air-launched several hundred miles from a target and will carry a nuclear warhead. Latest tests were air-launches from a Boeing B-52.

SAGE-Guided Genie Intercepts Drone

Eglin AFB, Fla.—Flexibility of the Norad SAGE air defense system has been demonstrated by the simultaneous tracking and interception of two QF-80 target drones, one by a ground-to-air Bomarc A missile, the second by an air-launched Douglas MB-1 Genie.

The first drone was destroyed by the Boeing-built Bomarc, launched from nearby Santa Rosa Island. Genie, launched by a McDonnell F-100 Voodoo, scored a programed near miss on the second drone.

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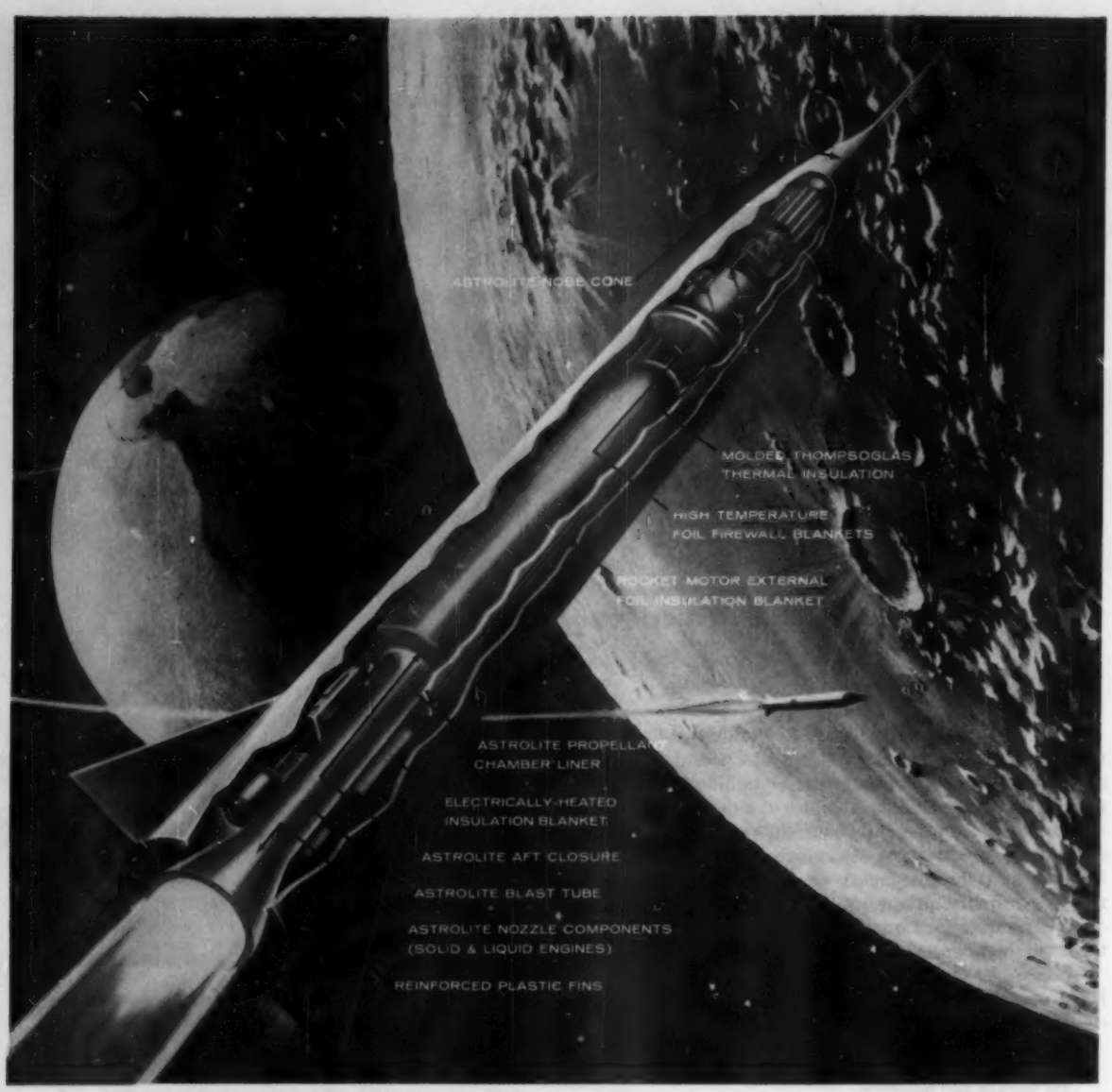
CIRCLE NO. 177 READER SERVICE CARD 177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Automatic System Supplies Mace Units

Robins AFB, Ga.—A system designed to provide rapid, efficient supply service automatically to Martin TM-76A and TM-76B Mace missile units from a single control point at Warner Robins Air Materiel Area is now in operation in the U.S. Zone of the Interior.

The system, called Project MAST (Missile Automatic Supply Technique), will soon go into operation overseas.

MAST will serve to test generally the feasibility of using modern electronics and communications equipment as the foundation for a new, completely integrated weapon system supply operation. If successful, it could establish the pattern for future weapon system support operations for almost all missiles in the U.S. arsenal. MAST may also prove applicable to manned aircraft.

How MAST Operates

This is how MAST will work in the case of the Mace:

There will be two contractor storage sites which will have responsibility for production, modification, storage and repair of support items for the Mace weapon system. One site will be maintained by Goodyear Aircraft (for ground support equipment and Atran guidance components) at Akron, Ohio; the other, by the Martin Co. (for airframe parts) at Baltimore, Md.

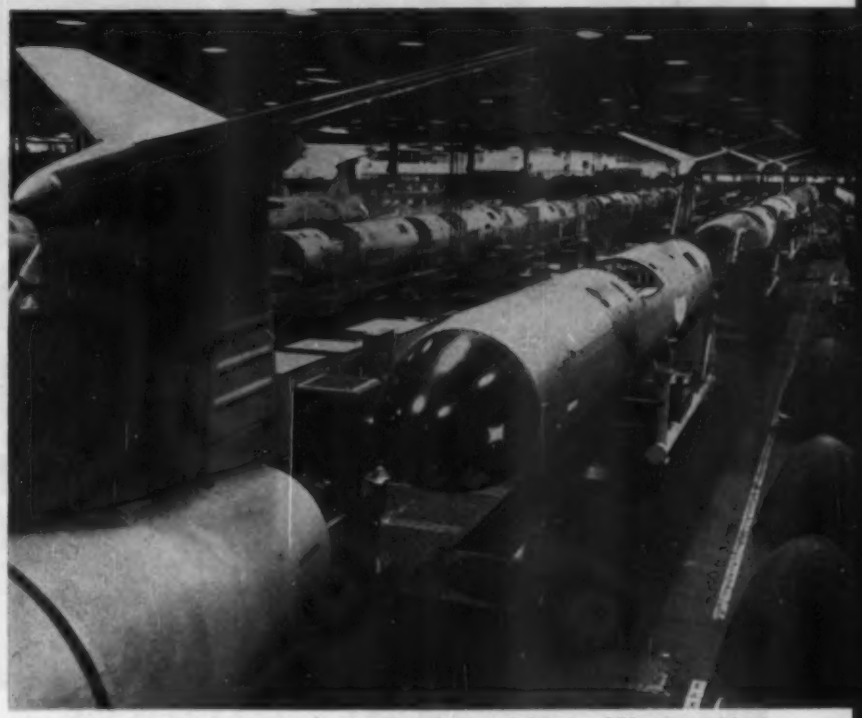
Control of the entire operation is centered at Warner Robins Air Materiel Area which has been designated the missile center for the Mace weapon system by Air Materiel Command headquarters.

The three most important items located here are the LSM-S (Logistic Support Manager-Supply); the individual—in this case, Frank A. Morrin, Jr.—in charge of the operation; the EDPE (Electronic Data Processing Equipment), at present an IBM 650; and a supply depot.

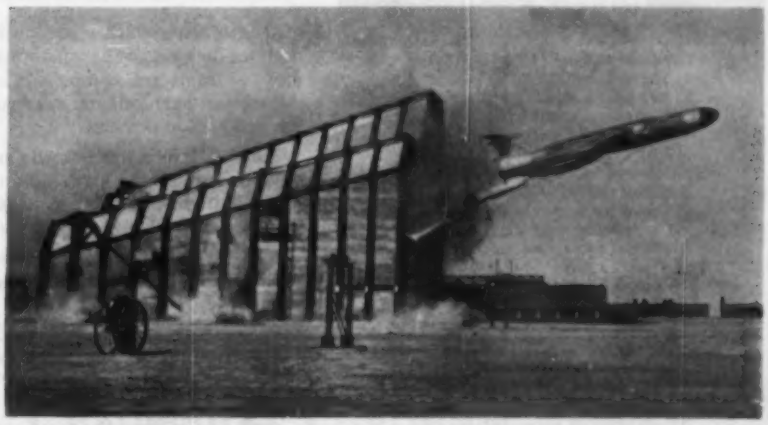
Larger than either contractor depot, the supply depot at Warner Robins stores all common items—Air Force supply items—common to more than one weapon system, such as typewriters, and Mace items not manufactured by either Martin or Goodyear, such as engine components.

In actual operation, Project MAST will proceed (in a somewhat simplified situation) as follows:

• **When a Mace group** is activated, the logistic support manager-supply and his staff compile and publish a weapon system stock control list (WSSCL) for the group. This consists of all items re-



PRODUCTION LINE view at the Martin Co. plant at Baltimore, Md., shows Martin TM-76 Mace surface-to-surface missile in varying stages of construction. Note configuration of the missile's T-tail at left foreground. Third missile in line shows the dish antenna used in the Mace self-contained guidance system called Atran (Automatic Terrain Recognition and Navigation) developed by Goodyear Aircraft Corp. (AW June 23, 1958, p. 53). The system involves airborne radar and compares what it "sees" with actual or simulated radar photos made of the terrain prior to the flight, to determine whether the Mace is following course. The Mace is replacing Martin Matador TM-61 missiles in operational units of U. S. Air Force's Tactical Air Command in West Germany. Weapon can carry a nuclear warhead more than 650 mi. at a speed of better than 650 mph.



USAF-MARTIN TM-76 Mace surface-to-surface missile is launched from a simulated shelter during Air Force tests in New Mexico. Mace now is being deployed in West Germany. The Mace, an improved Matador, has high and low altitude capability and can be equipped with a nuclear warhead.

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quired for the direct support of the Mace weapon system for 15-60 days, depending upon the geographical location of the site.

• **All this information** is key-punched into a Basic Record Establishment Card along with a predetermined reorder level for each item. Cards from each of the missile sites go to make up a master deck and are coded onto a master record for the IBM 650.

• **Every time** an item is used, the materiel officer at the missile site where it is used reports the fact on an electronic accounting machine card. At the end of the day, these cards are fed into the transceiver network that ties all Project MAST stations together. At Warner Robins, transceiver equipment punches out the information from the sending electronic accounting matching card on another EAM card.

• **The EAM cards** with the information on the items used are fed into the computer along with the master deck. After the master deck is brought up to date, computer checks the remaining stock against the predetermined reorder level. If the balance of items in inventory have fallen below the reorder level, the computer determines the resupply requirements and searched the file of the appropriate storage site to determine whether the required items are available.

• **If the items** are available, the computer automatically punches out an order for them which goes over the transceiver hookup to the appropriate storage depot. At the end of the day, the computer issues a complete transaction list which goes to the logistic support manager-supply and keeps him informed as to what took place during the day.

• **When the required items** are not available for a storage depot, the computer reads out a NSA (no supply action) card which goes to the support manager's office. After the support manager locates a source of supply, he can place his order by telephone or telegram in the case of a high priority or emergency requirement and then bring the computer up to date by preparing a NSA Input Card (Post-Posted). Or he can process his order through the computer by making out an NSA Input-Forced Action Card.

As complicated as this procedure may appear, Morrin says Project MAST is actually more direct and efficient than present support operations. For one thing, it eliminates all intermediate supply groups. Under the proposed MAST arrangement, the Mace site is in direct contact with the prime depot and requires no support (except for housekeeping) from the usual base supply, theater or zonal depots.

Another advantage of Project MAST, says Morrin, lies in fact that all funda-

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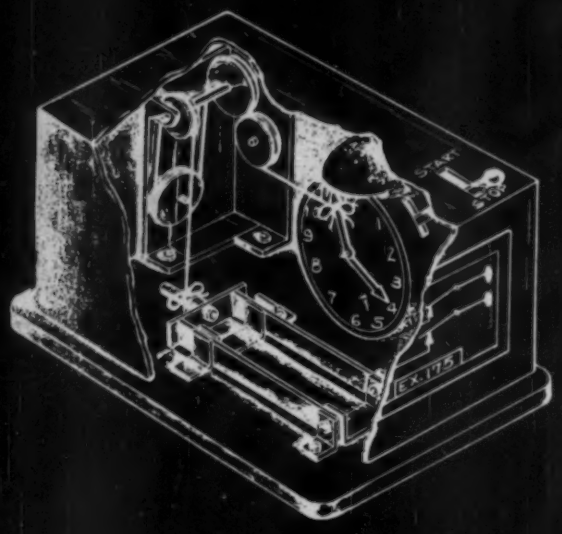

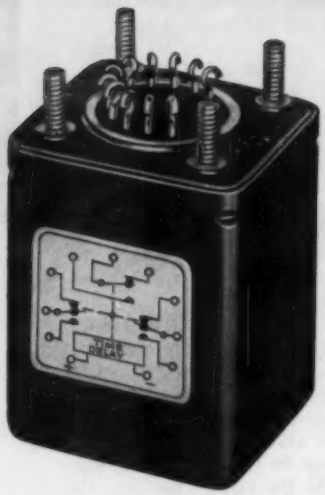

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mental cost and item data is located in a single basic card deck or machine tape. The handling, sorting and comparison of data constitutes a major part of a support workload.

Site bookkeeping, in particular, is greatly simplified and kept to a minimum. By having their supply needs anticipated, so to speak, by the computer, site personnel are free to devote more time to their prime mission of missile operation, while being assured of rapid and adequate support. The need for highly trained logistics personnel, intensified by the growing complexity of today's weapon systems, is significantly reduced by the use of machines and is generally limited to the headquarters group where the programming and most of the bookkeeping now takes place.

Project MAST is also expected to lead to a significant reduction in present support costs. In addition to reducing the amount of record maintenance and administrative personnel required and eliminating the usual intermediate support agencies such as base supply, MAST, in conjunction with airlift, can also save storage costs and material waste by greatly lessening the size of the required initial support package.

Logistic Planning

At present, Air Force logistic planning is generally based on one of the two following approaches:

- **For manned aircraft,** the Air Force initially purchases an 18-month support package; i.e., the amount of supply items that its logistic personnel have calculated the base aircraft will require during the first 18 months of operation. After that, support requirements are computed and purchased on an annual basis based on the aggregate of programed flying hours. Owing to the fact that manned aircraft operate continually, and under varying conditions, it is almost impossible to calculate support requirements on an operating life basis without allowing for a large and costly margin of error.
- **For missiles,** on the other hand, the logistic policy is to compute and purchase the initial support package on a "first line life" (five years) basis; i.e., buy and place in the field all the support items that the missile is expected to require during its five-year operational life. There are no provisions for subsequent support replenishment purchases except in unusual and critical circumstances.

The difference between the two approaches is believed to stem from the fact that missiles, unlike manned aircraft, are designed to perform just once, and thus require maximum positive support up to this time. Also, because missiles require relatively few spare parts to remedy malfunctions

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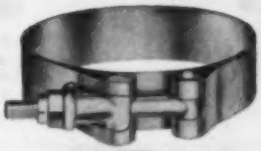

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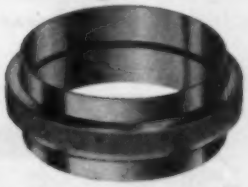

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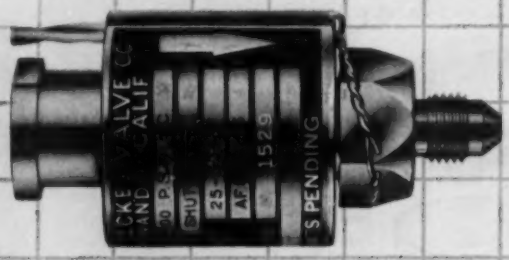
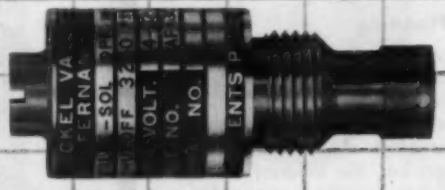
the leader in special small valve designs

Eckel valves, which first introduced the coaxial solenoid valve for aircraft and missiles, are now handling the principal rocket and missile fuels, oxidizers, and helium under extreme conditions, the latest being hydrogen peroxide for classified small rocket motor propulsion.



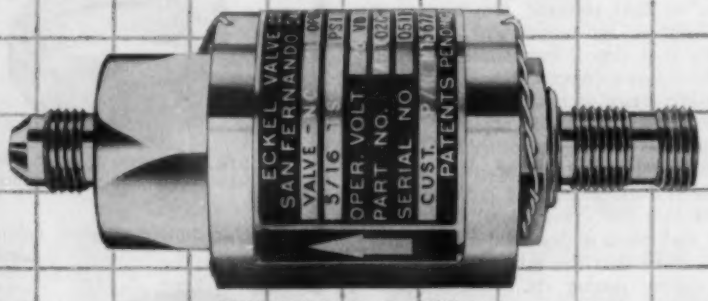
AF 56C Thousands of these valves have been made for Nike Hercules APU fuel control. Now also handling hydrogen peroxide for classified space projects.



AF 63C Pilot valve for helium regulator in major ballistic missiles. Maintains almost 0 leakage of helium at −420° to +290° F.

ACTUAL SIZE PHOTOGRAPHS

AF 53C Valve "buried" in a coupling of the fueling umbilical cord for a major missile to blow the coupling apart prior to launch. Handling RFNA and UDMH.



AG 102C High pressure full flow piloted poppet valve for almost any fluid. Will actuate as a direct acting valve with loss of pressure differential.

Other Eckel designs include:
the smallest solenoid shut-off valve — 0.8 oz.;
a 3-way valve weighing 0.9 oz.;
extremely low power consumption valves;
special manifold mounting and valves to "bury" in castings.

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found during maintenance inspections and because the number of these periodic inspections is usually set, life-time support requirements can be calculated comparatively accurately and one-time support procurement is feasible.

Project MAST officials disagree. There are, some point out, big differences between various types of missiles. While the current "first line life" concept seems practical for the small missiles, they say, the MAST approach is better suited to the large missiles which require a large number and wide variety of spare parts.

On a "first line life" basis, they contend, there is always the danger of overbuying, particularly with the large, complex missiles. As a result, storage costs will be greater than necessary and, in long-term storage, many materials will deteriorate. Then there is always the factor that the missile will eventually become obsolete.

Used in conjunction with airlift transportation, Project MAST may shorten the present supply time to a point where a missile (or manned aircraft) site can operate with only a 16-60 day stock of support items on hand. By eliminating the need for "first line life" support and enabling the site to obtain maximum positive support with a smaller initial procurement (along with essential replenishment purchases), Project MAST, its advocates maintain, probably will save the Air Force a great deal of money.

Supersonic Transport Rocket Tests Planned

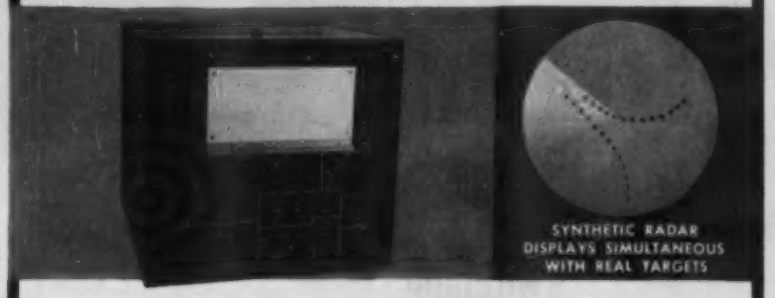
London—Armstrong Whitworth's "Flutter Dart" rocket test vehicle may be used in design of the first British supersonic transport. The vehicle already has provided some aerodynamic data for the project.

Vehicle radios data back to the ground during flights in excess of Mach 1. Equipment includes analog-to-digital and digital-to-analog converters to convert signal voltages into numbers and vice versa. Data now can be directly fed into computers for fast analyzing.

Republic Division Gets Missile Defense Contract

Research and development contracts for ballistic missile defense system centering on decoy discrimination and target destruction have been awarded to Missile Systems Division of Republic Aviation Corp. Amount is in excess of $300,000. Company said one method under investigation involves "invisible destruction curtains" in space, harnessing of radiation to cause internal damage to missiles.

a new, versatile method of creating air traffic for SOLVING AIR TRAFFIC CONTROL PROBLEMS



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Now operating in the field, this *operational digital* target simulator — which is available in either the range-azimuth or the x and y coordinates technique — is ideally suited to a number of applications, including: creating of synthetic test problems for air traffic control equipment; training radar operators in tactical procedures; calibrating radar systems; testing radar indicators; and other related uses.

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time / delay / relays

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The folder gives operating and environmental specs, coil data, contact capacities, dimensions, diagrams of contact and wiring arrangements. *Write:* Dept. A33-635.

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Elizabeth, New Jersey

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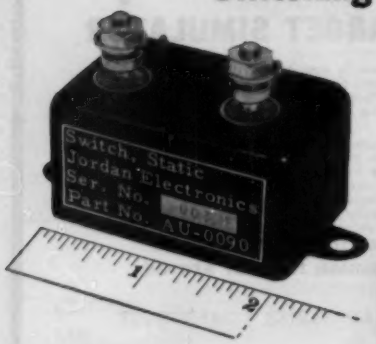
–for firing squibs, and high current switching



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LONG LIFE—No bounce—no arcing—no wear.

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3025 W. Mission Rd., Alhambra, Calif.

Second Recovered Re-Entry Nose Cone Displayed

Second RVX-1 materials research vehicle to be recovered in the Phase II Thor-Able firing program is shown at the Missile and Space Vehicle Department of General Electric, Philadelphia, which developed the vehicle and ablative coating. Ablative material does not show the flowing back from nose as did the ablative coating developed by Avco Corp. and used on the first re-entry vehicle to be recovered (AW May 25, p. 30). Note signs of light temperature at skirt (bottom).

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Electrosnap Corporation
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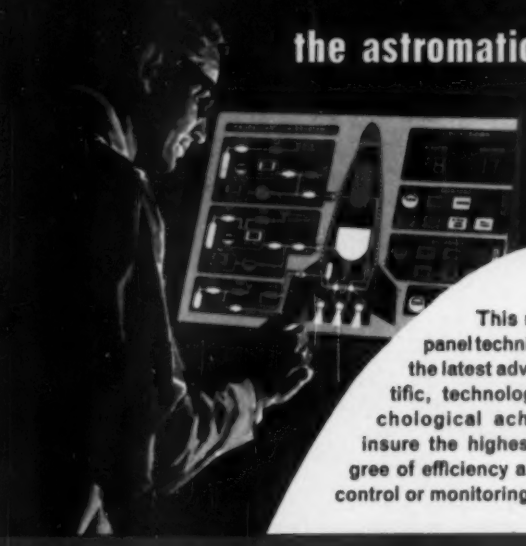

This new concept in panel techniques combines the latest advances in scientific, technological and psychological achievements to insure the highest possible degree of efficiency and accuracy in control or monitoring of equipment.

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for highest efficiency with maximum accuracy

100% FLUSH PANEL . . . Eliminates protruding hardware . . . unless specified by human engineering requirements. Switching functions may be recessed, flush, or over-flush.

TRI-COLOR LIGHTS . . . Each light module contains 3 separate bulbs and circuits to permit triple indications such as GO, NO-GO and CAUTION signalling.

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LIMITLESS COLOR COMBINATIONS . . . The unique combination of TRILITES plus multi-color photo printing of panel allows unlimited color guidance, distinctly identifiable even by color blind.

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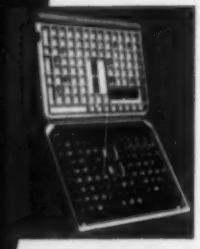

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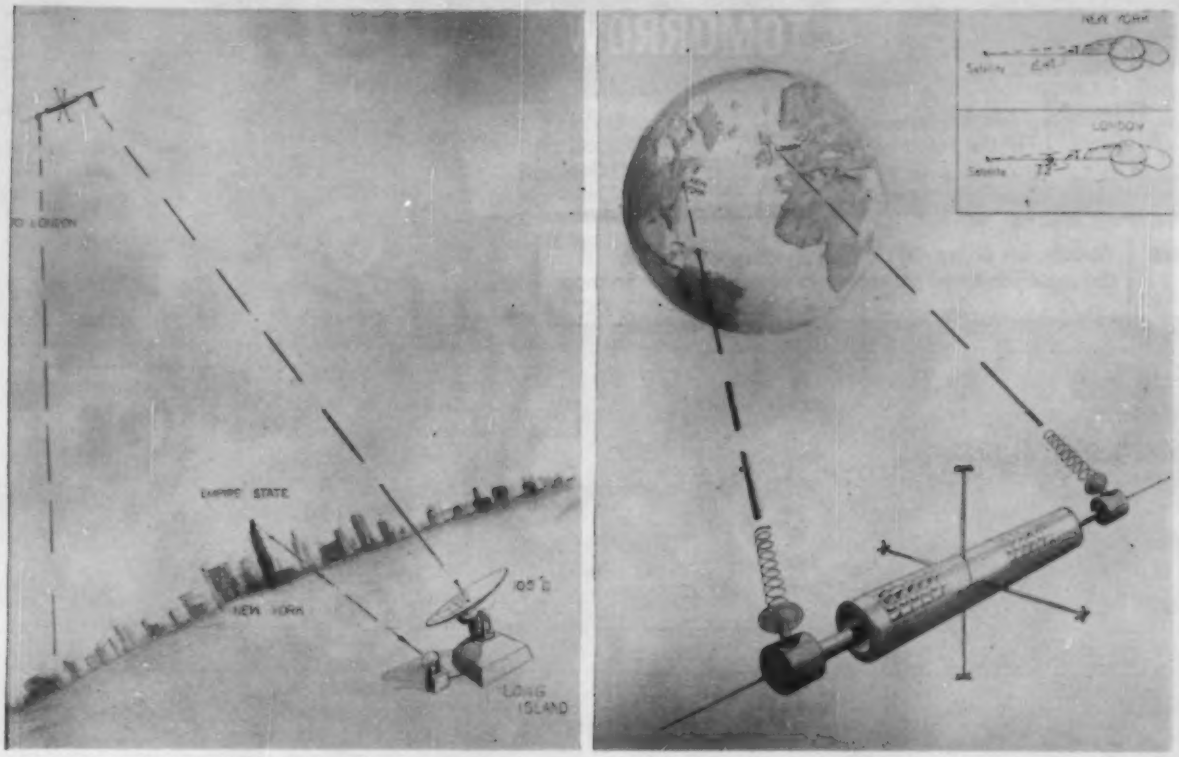


COMMERCIAL COMMUNICATIONS satellite for transatlantic use, proposed by Space Electronics Corp., would provide 125 voice channels, one TV channel; 500 lb. satellite would be placed in 22,300 mi. equatorial orbit to hover over mid-Atlantic by Vega type booster.

Civil Communication Satellites Studied

By Philip J. Klass

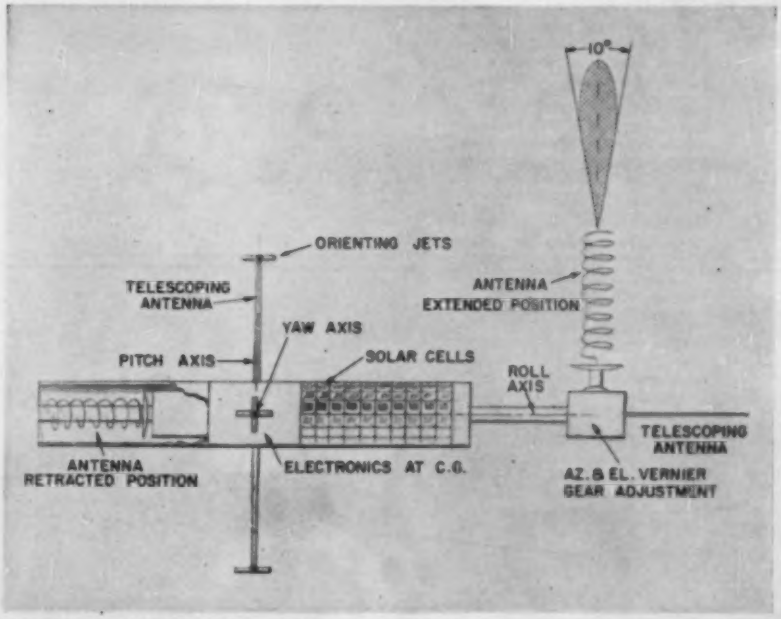
Washington—Technical economic studies aimed at the application of communication satellites to commercial long-distance communications and intercontinental television are now being conducted by a number of companies, indicating that this may be one of the first space age byproducts to make an impact upon the nation's way of life.

The list of companies is known to include American Telephone & Telegraph Co., General Electric, International Telephone & Telegraph Corp., Radio Corp. of America, Space Electronics Corp. and Westinghouse Electric.

AT&T Effort

For example, AT&T's Bell Telephone Laboratories now has eight scientists working full time on commercial communication satellite studies, with many others devoting time to developments such as Maser amplifiers which would be used with these satellites as well as on other applications.

Space Electronics Corp., Glendale,



CYLINDRICAL SATELLITE would have retractable helical antennas for communications, telescoping dipole antennas for attitude stabilization. Solar cells generate electric power.

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ARPA Communication Satellites

Here are the highlight characteristics of hovering (22,300 mi.) equatorial active communication satellites under development by Advanced Research Projects Agency.

	Immediate	Long-Range
Capacity:	144 voice channels	300 voice channels, or two TV channels.
Payload weight:	625 lb.	8,000 lb.
Operating frequency:	2,000 mc.	2,000-2,300 mc.
Satellite transmitter output:	20 watts	150 watts
Satellite antenna size:	2 ft. dia.	?
Ground antenna size:	28 ft. dia	28 ft. dia.
Ground transmitter power:.	1,000 watts	?
Estimated development completion:	June, 1963	June, 1968

Calif., already has approached a number of companies and a major Wall Street investment house in an effort to drum up speedy action in applying existing military-developed technology to commercial communications.

The company's effort is sparked by its president, Dr. James C. Fletcher, who formerly headed Space Technology Laboratories' electronics laboratory. Fletcher hopes to arouse the interest of a ballistic missile manufacturer, an avionics company and a communication services operator. Space Electronics Corp. also is pioneering in the application of subsurface electromagnetic waves, called "earth currents," for military communications (AW May 18, p. 26).

Cost, Timetable

Within two years, Dr. Fletcher believes, it should be possible to have an operational active repeater satellite hovering in a 22,300-mi. equatorial orbit over the Atlantic.

Dr. Fletcher says such a satellite relay could provide 250 voice channels, five times as many as the recently installed transatlantic submarine cable, or 125 voice channels plus a 5 mc. television channel.

Dr. Fletcher estimates that the cost of developing the satellite, buying the Vega launching vehicles being developed under National Aeronautics and Space Administration sponsorship, establishing two ground stations and making the required number of experimental launchings can be accomplished for approximately $25 to $40 million.

Annual cost of replacing the satellite relay, assuming that two launches will be required to obtain one successful orbit, will run about $5 million, Fletcher believes.

He concedes that these estimates might be off by as much as a factor or two.

In recent testimony before the House Committee on Science and Astronautics, Robert P. Haviland described a system which would use 16 non-hovering active repeater satellites in 1,000-mi.-high orbit for complete global coverage. Satellites would provide 200 teletype channels, considerably less bandwidth than the satellite Space Electronics proposes. Haviland estimated it would cost $100-150 million to place the system in operation and about $50 million annually to replace the 16 satellites.

Dr. Henri G. Busignies, president of International Telephone & Telegraph Laboratories, told the House committee that his company has made preliminary analysis of the cost of a global system using three hovering active repeater satellites at a 22,300-mi. altitude. The IT&T study considered satellites with channel capacity ranging from 48 duplex voice channels up to 500 duplex voice channels, or 250 duplex channels plus one television channel.

Estimate Basis

The IT&T analysis was based upon construction of 12 ground stations for global coverage, each costing about $2 million.

In Space Electronics' estimate, the figure of $1 million each was used.

Assuming four misfires before the first satellite was successfully placed in orbit, Busignies estimated it would cost $20 million to place first the repeater in a 22,300-mi. orbit. This figure checks closely with Space Electronics' estimate. With experience, the number of misfires should come down, reducing the cost of placing subsequent satellite repeaters in orbit, Busignies said.

Busignies also estimated that a global satellite communications system with 48 duplex channel capacity would cost approximately $665 per channel per mile, while a 500 channel system would cost around $55 per channel per mile. The cost of submarine cable is "between these values," Busignies said. The frequently quoted figure is approximately $400 per channel per mile for

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. . . Or atomic assemblies and components? . . . Reactor core lifting and other core handling equipment, welded pressure vessels and small machined parts are all produced by Bliss.

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Availability: excellent. Allied is a major producer of Nitrogen Tetroxide, can ship immediately in cylinders or tank car lots. Allied also produces ammonia, ethylene oxide and methanol for the rocket industry. Write for technical or other information you desire on any of these products.

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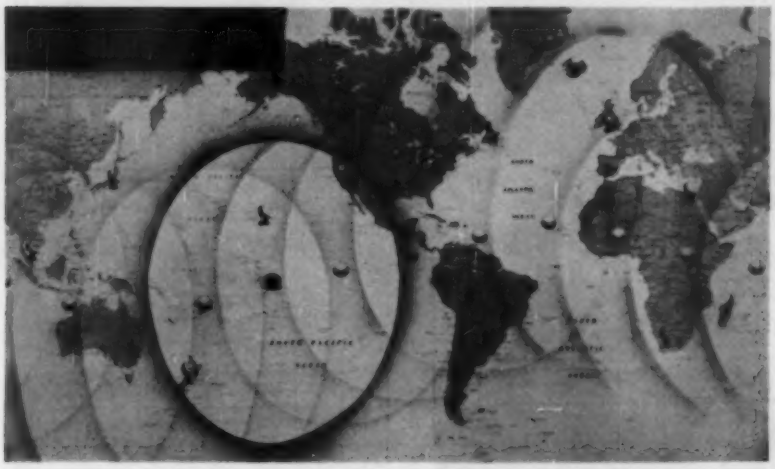
transatlantic cable.) Busignies conceded that the figures were engineering guesses and not necessarily a very accurate cost figure.

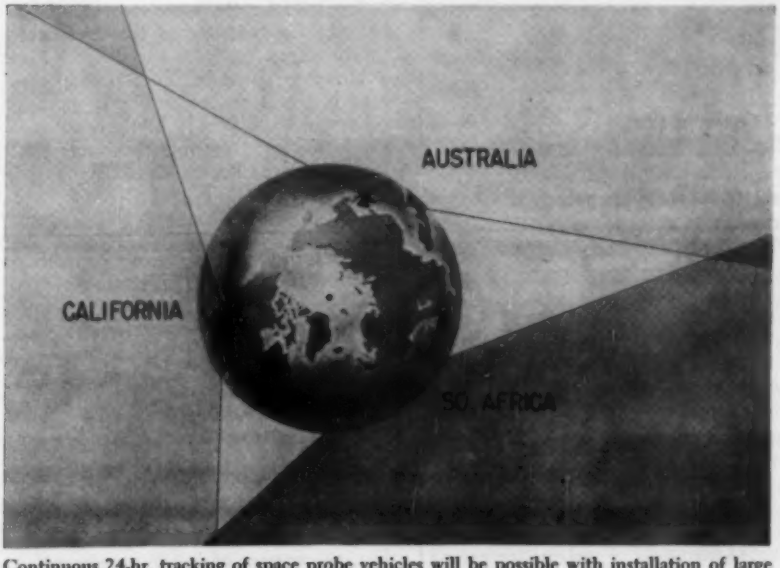
Some observers believe that Dr. Fletcher is being overly optimistic in suggesting that now is the time for private industry to proceed with a commercial communications satellite, particularly one of the active (repeater) type in an 22,300-mi. equatorial orbit. They suspect that putting a satellite into such an orbit, and keeping it on station, may prove more difficult than anticipated.

Observers also point out that the Advanced Research Projects Agency already has such a program under way for military use (AW April 27, p. 28). They question the wisdom of privately financing a program with so many unknowns rather than waiting for the results of ARPA's program. Fletcher's timetable of two years also comes under fire from some observers, who point out that ARPA doesn't expect to place its



NASA Plans Communications Satellite

Coverage area for passive communications satellite in a 3,000 mi. high orbit shows that two ground stations up to 4,000 mi. apart can communicate by bouncing radio signals off the aluminum-coated plastic sphere. For example, a station in New Zealand could communicate with one in California when satellite is in position shown in heavy lines. National Aeronautics and Space Administration hopes to place 100 ft. diameter passive communications satellite in a 1,000 mi. high orbit this year.



Continuous 24-hr. tracking of space probe vehicles will be possible with installation of large 85 ft. diameter tracking anteanas in Australia and South Africa, similar to one now installed at Goldstone in California. National Aeronautics and Space Administration's Fiscal 1960 budget seeks funds for the Australian and African trackers.

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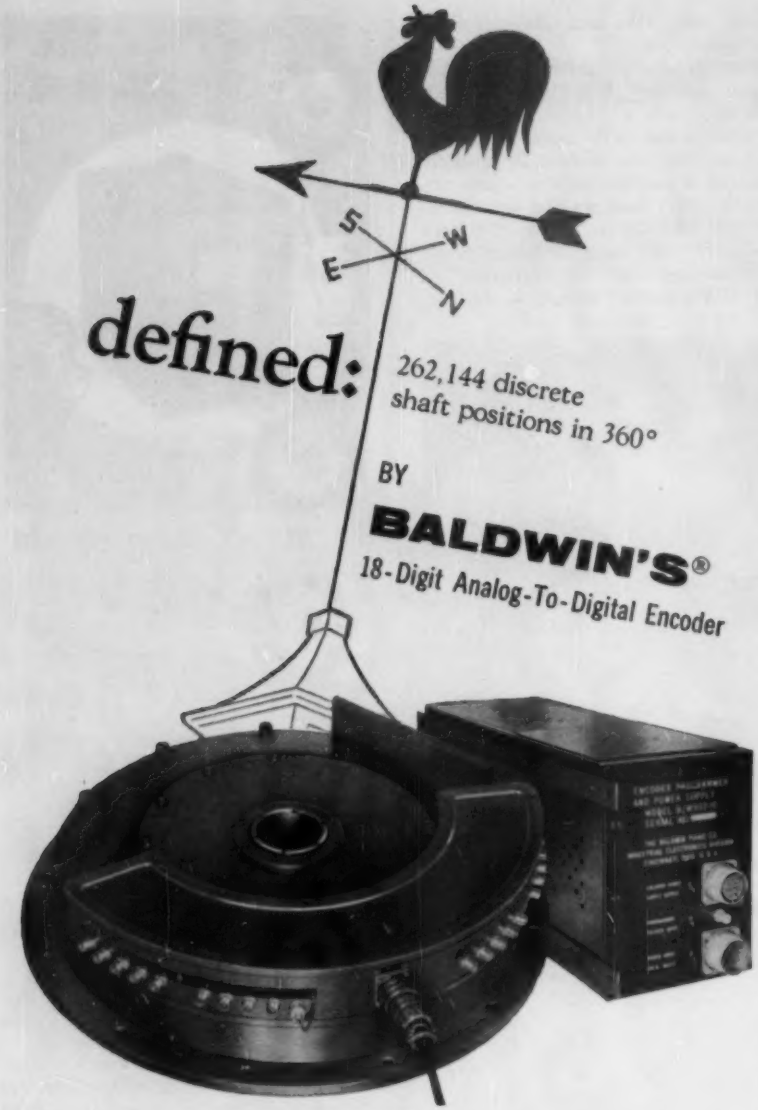

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Also available are three sizes of the Baldwin 13-Digit Encoder and two models of the Baldwin 16-Digit Encoder. Encoders with decimal, trigonometric functions and other nonlinear codes can be supplied. Write for full details and descriptive literature.

INDUSTRIAL PRODUCTS DIVISION
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1808 GILBERT AVE., CINCINNATI 2, OHIO

first repeater satellite into a hovering orbit for three years.

Fletcher's response is that he believes private industry can move more rapidly, and probably more economically, without the red tape inherent in any government-financed project. Fletcher concedes that he is an enthusiastic booster of communication satellites, being motivated in part by concern over the international impact if the Soviet Union becomes the first to place such a system into operation. Fletcher points out that Space Electronics Corp. has little to gain if the idea is picked up, since at most the company would participate only in an advisory capacity.

Company Proposal

Space Electronics Corp.'s preliminary technical proposal calls for a 500 lb. payload in a 22,300-mi. orbit using a four-stage rocket. First two stages would be the NASA Vega, consisting of a modified Convair Atlas ICBM first stage and an improved General Electric Vanguard second stage. The NASA launcher is expected to have the capability of putting a 740 lb. payload into a 22,300-mi.-high orbit. The third-stage would be a solid-fuel rocket with short burning time which would be used to transfer the payload from an initial 300-mi. orbit to the 22,300 mi. altitude. Fourth stage would provide the final increment of velocity needed to achieve orbit.

Guidance during the initial ascent could be provided by existing General Electric ballistic missile guidance systems installed at the Atlantic Missile Range, Cape Canaveral, Fla., and at San Salvador. If the vehicle is allowed to make one complete low-altitude orbit before transfer, the same stations might be used for guidance of the third and fourth stages.

However, a more conservative approach, the company says, is to use another guidance facility in the southern California area, possibly the one being installed at the Pacific Missile Range.

Range Facilities

Although the company's cost analysis includes the cost of buying launching rockets, it assumes that arrangements could be worked out to use existing government missile range facilities for launching and at least initial guidance. This might be handled by arranging to exchange use of these launching facilities for the use of the commercial satellite relay for such government needs as Voice of America, Dr. Fletcher says.

Although Space Electronics Corp.'s proposal does not specify the operating frequency for the communications satellite, a frequency of 1,000 mc. is used as one possibility in computing performance. At this frequency, for instance, 105-ft. diameter antenna dishes located

PROJECT STAR

In 2000 B.C. man sought to chart the heavens and created the Zodiac, an imaginary belt, which was believed to control his destiny . . . Today, man, no longer willing to surrender his fate to the stars . . . seeks to explore them instead.

America's determination, to win the race for space is evidenced by the formation of projects such as Airborne's STAR (Space Technology and Advanced Research). Here in our Laboratory a hard core of scientists and engineers are designing electronic systems for space vehicles. These programs are not company proposals, but firm orders of continuing duration for customer hardware. The esoteric nature of each piece of equipment places a premium on technical skill and ingenuity, as normal engineering procedures become overwhelming problems when transferred to the unworldly vacuum of space.

Project STAR is a culmination of our long-standing interest in electronic research and development. Space technology, and other new challenging areas open to electronic engineers at Airborne, have created select positions in the following fields:

Advanced Electronic Design Engineering • Product Design • Operational Analysis • Data Processing • Reliability • Circuit Design • Electronic Counter-measures • Field Engineering • Radar Systems • Antenna Design Systems Analysis and Management • Microwave Systems • Systems Test

General Benefits Program and Relocation Expenses. Send resume to Howard J. Gresens who will arrange a technical interview at your convenience.

AIRBORNE INSTRUMENTS LABORATORY

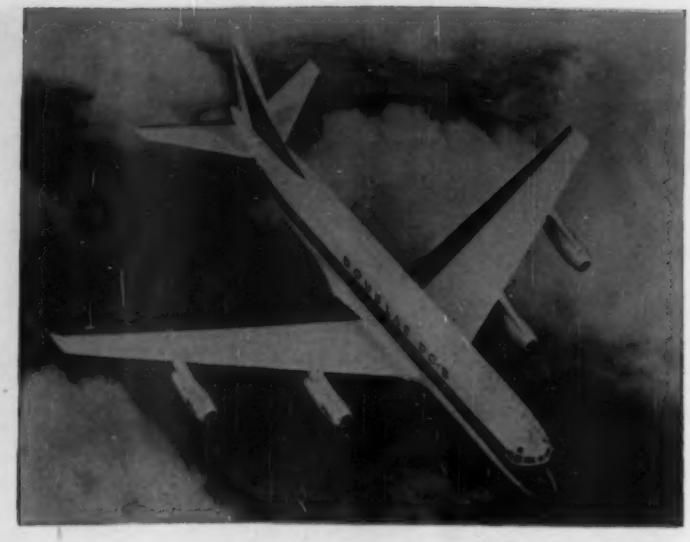
A DIVISION OF CUTLER-HAMMER, INC.

Garden City, L. I., N. Y.

Myrtle 2-6100

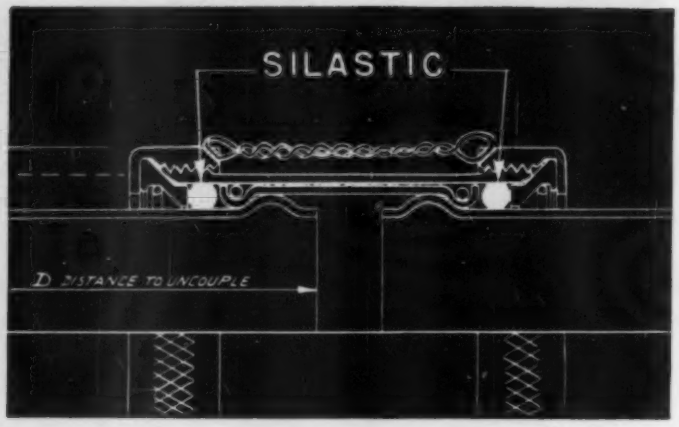
The PLANE

New Douglas DC-8 Jetliner, soon to enter commercial service with 18 of the world's leading airlines. The four-jet DC-8 cruises at 560 to 590 mph, carries 118 to 176 passengers, and will cross the Atlantic non-stop from New York to Paris in just over six hours. Fuel capacity on international flights exceeds 21 thousand gallons.



The PROBLEM

Coupling and sealing hundreds of joints in the DC-8's fuel lines. These couplings must be flexible and leakproof. On Mark Couplings, Incorporated, Los Angeles, the coupling designer, prevents leakage with rubber O-rings. For these O-rings, Douglas tested standard rubbery materials for fuel resistance, thermal stability, resistance to abrasion, weathering, compression set, and shrinkage after fluid immersion and dry out.



The PART ....SILASTIC

Test requirements for the O-rings were met by a special compound based on Silastic® LS-53, the Dow Corning fluorocarbon silicone rubber. This was the only material to stand over 1,000,000 cycle flexings without leakage.

TYPICAL PROPERTIES OF SILASTIC LS-53

Temperature range, °F	−80 to 500
Compression set, %, 22 hrs @ 300 F	22
Solvent resistance, % swelled	
ASTM No. 3 Oil, 21 days @ 300 F	3
Jet Fuel JP4, 15 days @ 250 F	18

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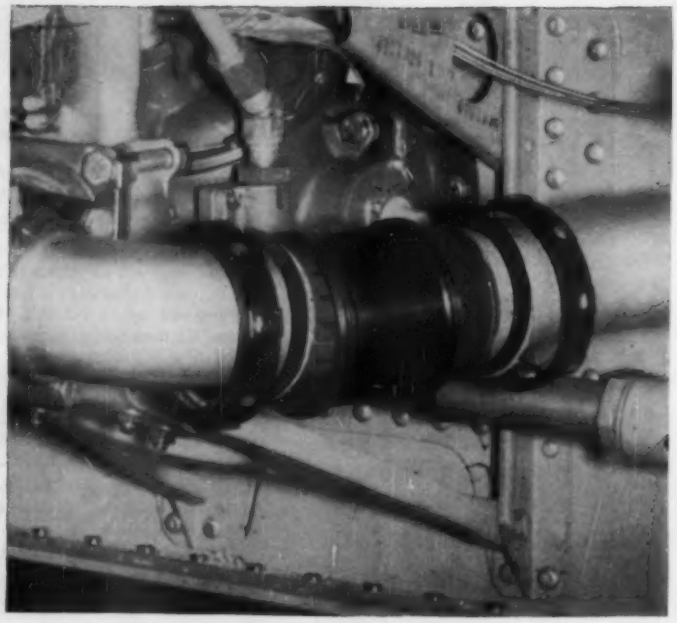

in New York and in London would provide a beamwidth of 0.7 deg., a gain of 50 db. and cost approximately $3 million.

Dr. Fletcher believes that an 85-ft. diameter dish, like the one now installed at Goldstone, Calif., for space probe tracking, probably would be adequate.

With the stations located in New York and London, the satellite would be located at approximately 37 deg. west longitude along the equator. Position of satellite could be determined with an error of no more than two and one-half miles, the company says, using existing AN/FPS-16 or AN/FPQ-4 precision military tracking radar.

Tentative satellite configuration proposed by the company is a cylinder with two retractable helical or parabolic antennas at either end which can be extended once the vehicle is in orbit (see sketch).

Through use of sophisticated modulation techniques, Fletcher says that satellite transmitter power can be held to a few watts, the exact figure depending upon such factors as the operating frequency, size of the earth and satellite antennas and whether a Maser or parametric amplifier is used at earth stations.

Solar cells distributed around the periphery of the satellite will generate required power while the satellite is exposed to sunlight (22 hr. and 45 min. of each day). If continuous 24-hr. service is required, batteries must be added which would be charged by solar cells during the sunlight exposure period.

Attitude Control

To minimize the satellite transmitter power requirement, Fletcher proposes to use high gain helical or parabolic antennas, but this, in turn, requires moderately precise control of satellite attitude with respect to the earth stations to assure that the vehicle antennas are continuously aimed at the stations.

Fletcher believes this can be accomplished by means of an auxiliary linearly polarized signal transmitted from the earth stations. Three pairs of telescoping dipole antennas, each pair mounted at right angles to the other two, could be used to measure satellite attitude relative to the linearly polarized wave transmitted from the earth station (see sketch).

Using small control jets operated from signals developed by the dipole antennas and small transistorized microwave receivers, it should be possible for the satellite to align itself automatically to within a few degrees of the desired attitude. At that point, more precise alignment can be obtained by utilizing the helical or parabolic antennas to seek the direction of maximum signal strength from the earth station, Fletcher says.

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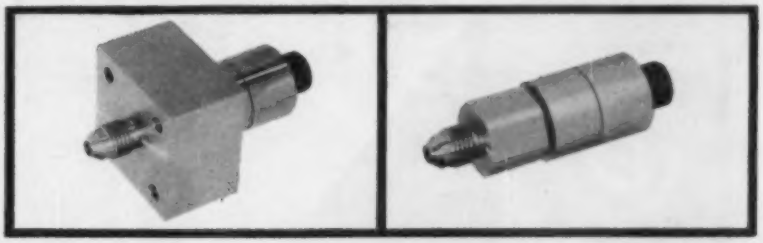

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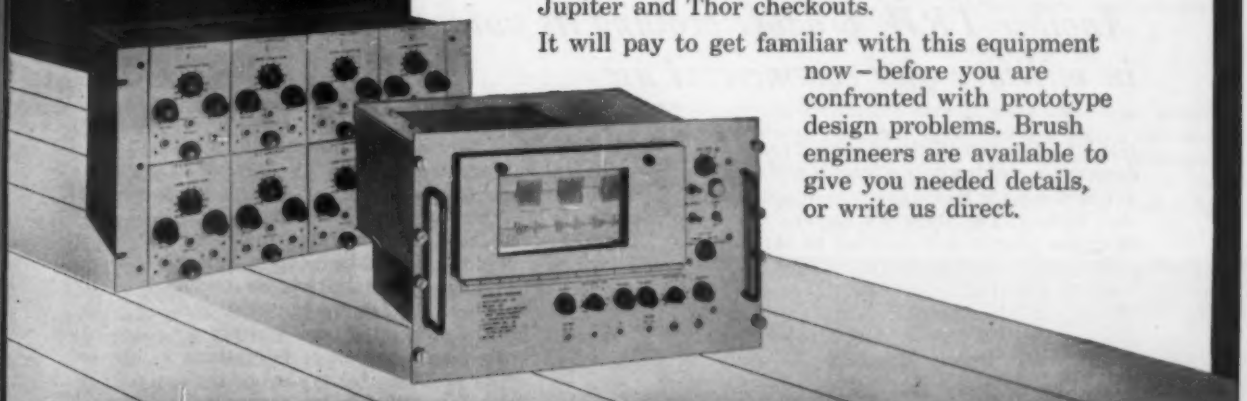

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The Dage camera in the F-102B chase plane provided "eyes" for thousands of spectators viewing the Air Force's World-Wide Weapons Meet.

The 10 lb. Dage camera, connected by closed-circuit to the home TV set, serves as a swimming pool monitor. It is available through Abercrombie & Fitch, New York, at $1495, including installation and one year's service.

To track a jet

or watch a child...

Another TRW product proving its value in military and commercial use

Not long ago a small closed-circuit television camera—weighing only 4 pounds and no bigger than a home movie camera—made television history. The Dage TV camera, carried in chase planes and located at strategic points on the vast gunnery range of the Air Force's Fighter Interceptor World-Wide Weapons Meet, recorded the supersonic flights of F-102s from scramble to kill. What it saw was transmitted back to TV screens in monitor stations.

In dramatic firsts like this, the Dage Television Division of Thompson Ramo Wooldridge Inc. is leading the closed-circuit TV field in number of installations and in technical achievements. Dage TV systems are being used to provide faster and more complete weather briefings for remote air bases, help control turnpike traffic, instruct salesmen, and aid in hospital education, surgical observation and consultation. Around the home, the Dage TV camera can be used in monitoring the swimming pool, watching the baby or the front door. Dage Television Division and its products are typical of the way Thompson Ramo Wooldridge serves its customers in meeting the demands of today's technology.

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Speedometer Proposed for Space Vehicle

By James A. Fusca

Little Falls, N. J.—Avionic companies throughout the country are investing their own funds to stake out proprietary claims in space.

Anticipating increasing Air Force emphasis on research and development for space—and more money for contracts—these companies are assembling technical personnel and working to acquire proprietary approaches to problems in space navigation, guidance, control and communications to better compete in this expanding avionics area.

Representative of these company-sponsored studies is an Astro Digital Doppler Speedometer proposed by Kearfott Co., Inc. The device, designed for space vehicle navigation, was described by J. E. Abate, Project Engineer in Kearfott's Astronautics Laboratory, at the National Conference on Aeronautical Electronics (AW June 1, p. 100). The company has submitted proposals on the device to Air Force and NASA and hopes to receive a contract.

The instrument measures the relative velocity of a space vehicle with respect to a star or the sun by measuring the Doppler shift of the star's spectrum. Three star fixes would enable a space navigator to compute position, direction of travel and velocity of his vehicle.

Principles of Operation

The spectrum of each star contains narrow lines at various wavelengths or frequencies that indicate absorption by different elements present in the star or its atmospheres. The movement of a star relative to the earth can be determined by the shift in frequency of these lines relative to their frequency in a spectrum generated by a laboratory source.

If a star is relatively approaching an observer, the lines of its spectrum are displaced toward the decreasing wavelength by an amount proportional to the velocity of approach. In the same manner the lines are displaced toward increasing wavelength if the star is receding. The velocity is considered to be negative if the star is approaching and positive if it is receding.

The proportional relationship between velocity and change in wavelength is only approximately true because of the effects of relativity, which cause a relative velocity to appear somewhat less if approaching the source and greater if receding from it. This evolves from Einstein's special theory of relativity which stipulates that the change in frequency is a function of velocity in higher powers than the first.

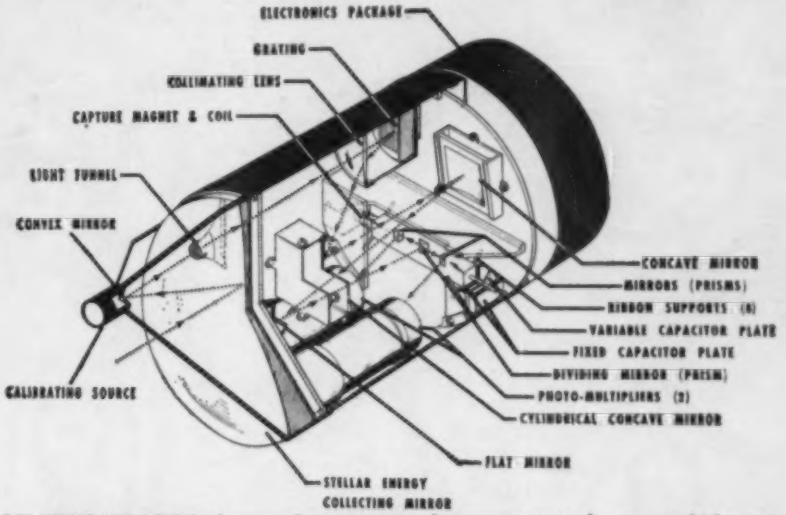
This error, however, becomes significant only if the relative velocity approaches the speed of light. For example, the error due to relativity for a velocity of 20 miles per second is approximately one part in 10,000.

Determining velocity relative to a star by means of Doppler shift requires instrumentation sufficiently sensitive to be capable of measuring very small changes in the wavelength of propagated light. The device proposed by Abate is made up of these elements:

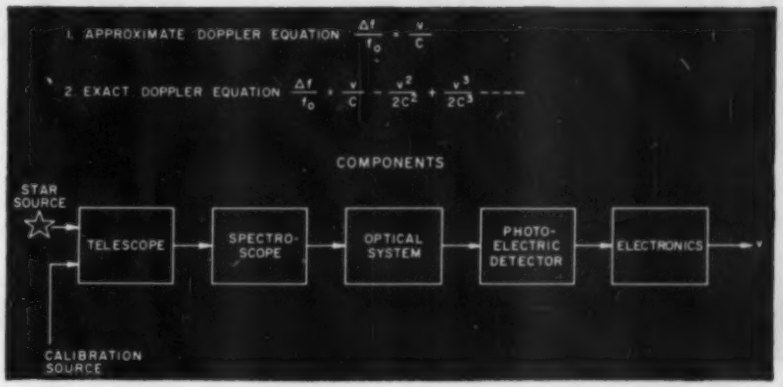
- **Telescope.** A telescope to collect and focus the light from the star.
- **Spectroscope.** A spectroscope to disperse the stellar energy into its various wave lengths.
- **Optical system.** An optical system which isolates and focuses on one particular wave length.
- **Photoelectric detector.** A photoelectric detector which detects the shift of the particular wavelength due to the Doppler effect and converts it into an electrical signal.
- **Electronics.** An electronic system which locks onto the Doppler-shifted signal and measures it to compute relative velocity.

System Problems

In designing a system to meet these requirements, Abate found it necessary to consider a number of related problems. The first was to compute the stellar energy available and determine the required energy level to produce a satisfactory signal-to-noise ratio. This is a function of the wavelength distri-



RELATIVE VELOCITY of approach or separation between a star and a space vehicle navigator is measured by means of the Doppler shift of the hydrogen gamma absorption line present in the star's spectrum. Device, called an Astro Digital Doppler Speedometer, has been proposed by Kearfott Co. Elements of the system are shown below. In Doppler equation, v is positive velocity (if source and observor are separating), c is speed of light, f_o is original frequency, and f is the Doppler-shifted frequency.

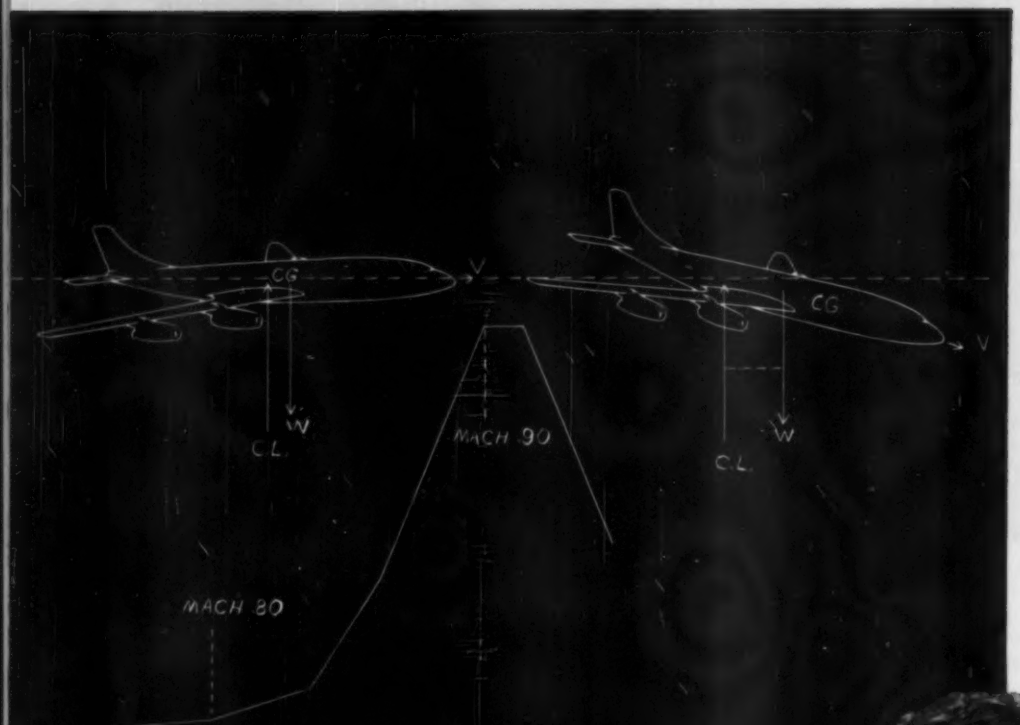


Another subsystem from Giannini...

Pitch Trim Compensator for the DC-8 Jetliner

As aircraft proceed into the Transonic Speed range, aerodynamic trim characteristics change. This change in trim requires an undue amount of attention on the part of the pilot. A small compensator system was developed by Giannini to apply continuous trim force which permits the pilot to trim the airplane in the normal manner.

The success of this small system, which was developed for use on the new Douglas DC-8 Jetliner, is largely due to the knowhow of experienced engineers and their familiarity with the Giannini precision-built components that went into its design. For additional data on the Pitch Trim Compensator, send for Giannini Systems Case Study No. 100.



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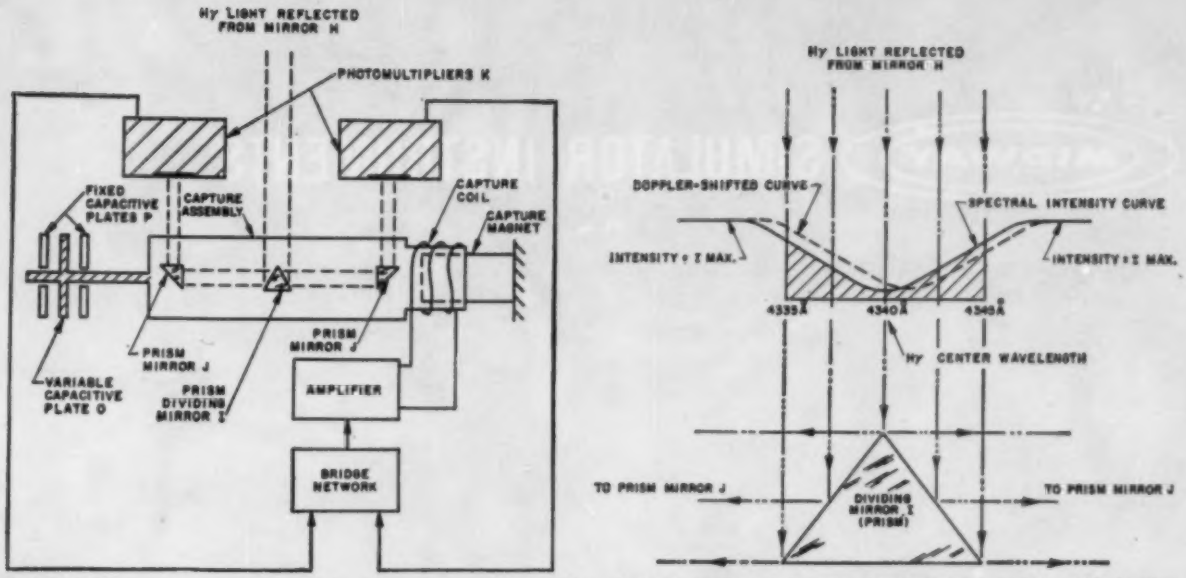
Engineering opportunities now exist at Giannini for work on similar systems. Write the Director of Technical Personnel.



SCHEMATIC drawing of the servomechanism and capture assemblies of the Astro Digital Doppler Speedometer is at left. Distribution of the wavelength part of the spectrum that includes the hydrogen gamma absoption line is shown in the drawing at right which indicates how Doppler shift of the hydrogen gamma line causes more light energy to reflect to a photomultiplier, generating an error signal.

bution of the stellar energy, the magnitude of the star, the size of the telescope, the efficiency of the spectroscope and optical system, and the threshold and noise of the photoelectric detector.

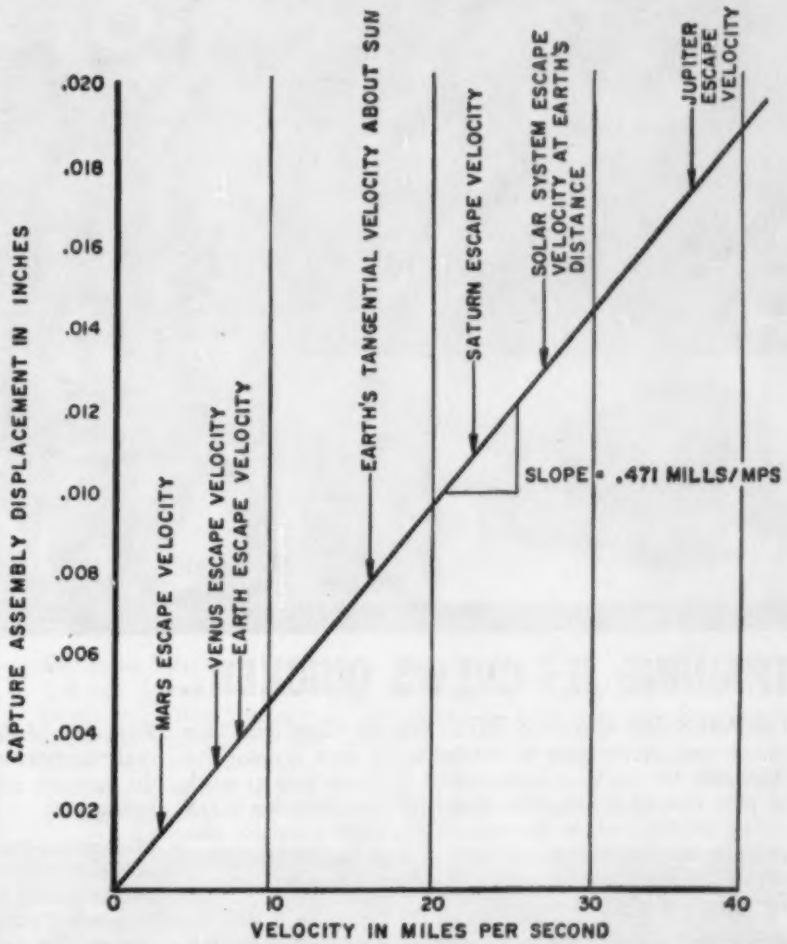
It was necessary to estimate the dispersion required of the spectroscope so that the amount of wavelength shift was large enough to be easily detected. This depends on the dispersing elements, the length of the optical path, the means of detection and the threshold sensitivity of the transducer used to convert wavelength change to electrical signal.

Measuring Device

It was necessary to determine what type of optical-electrical instrumentation was required to detect automatically and measure the small wavelength shift, and the amount of environment control required to compensate for mechanical and electrical instabilities such as thermal expansions, vibration, creep, shock, electrical drifts in gain, frequency and impedance.

The final design must pass the test of being sufficiently accurate and reliable, requiring little power, and be limited in size and weight to the extent required for space vehicle instrumentation. In its present form, Abate estimates that a model of the Astro Digital Doppler Speedometer (ADDS) would be eight inches in diameter with an over-all length of 15 in., would weigh about 11 lb., including power supply, and consume approximately eight watts of power.

Astronomers presently measure stellar velocity by the method of photograph-



GRAPH shows the relationship between relative velocity measured by the ADDS and the linear displacement of the capture assembly by the servo positioning system.

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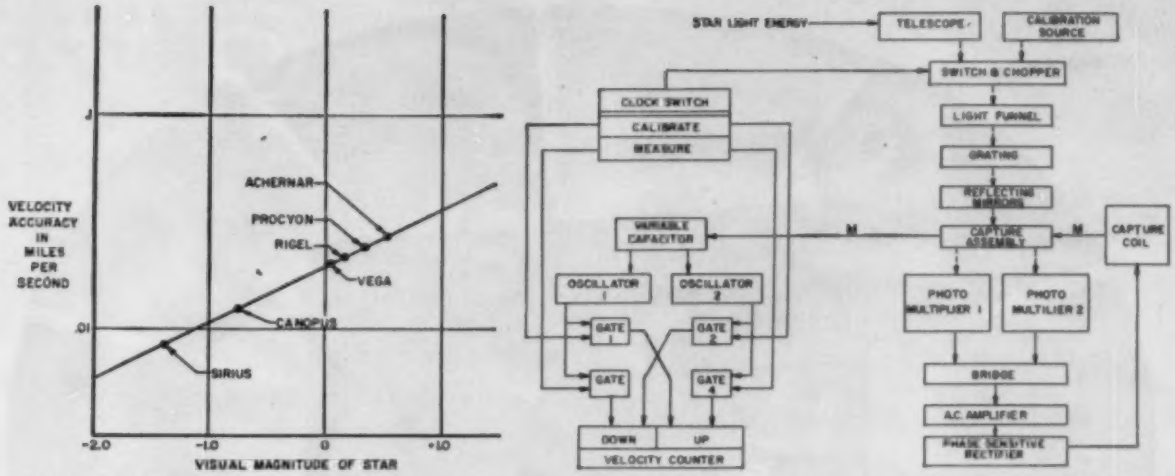

ACCURACY of velocity measurement as a function of visual magnitude of the observed star is shown (left). Calculations assume a signal-to-noise ratio of 3 to 1 and a velocity information rate of 1 cps. Functional block diagram of the complete system is at right.

ing on one plate both the spectrum of the star and the spectrum of a laboratory source such as luminous iron or titanium vapor. This photograph, or spectrogram, is placed under a microscope and the position of the star's spectral lines compared with those of the source. Because the spectral lines of the source have no Doppler shift, this micrometric measurement yields the relative velocity of the star.

This type of measurement is too complex and requires too much care and experience to be suitable for space navigation. What is required is a device to make these comparative measurements quickly and automatically, while eliminating the opportunity for human errors.

The ADDS system measures Doppler shift by means of a servo system that follows the shift of the stellar hydrogen absorption line (called the hydrogen gamma line), comparing it with a built-in reference and calibrating device. The servomechanism uses the balanced output from a pair of photomultipliers to capture the linear movement of the hydrogen gamma line, the magnitude of this change being a measure of the Doppler shift.

The hydrogen gamma line (at 4,340.465 angstroms) is used with

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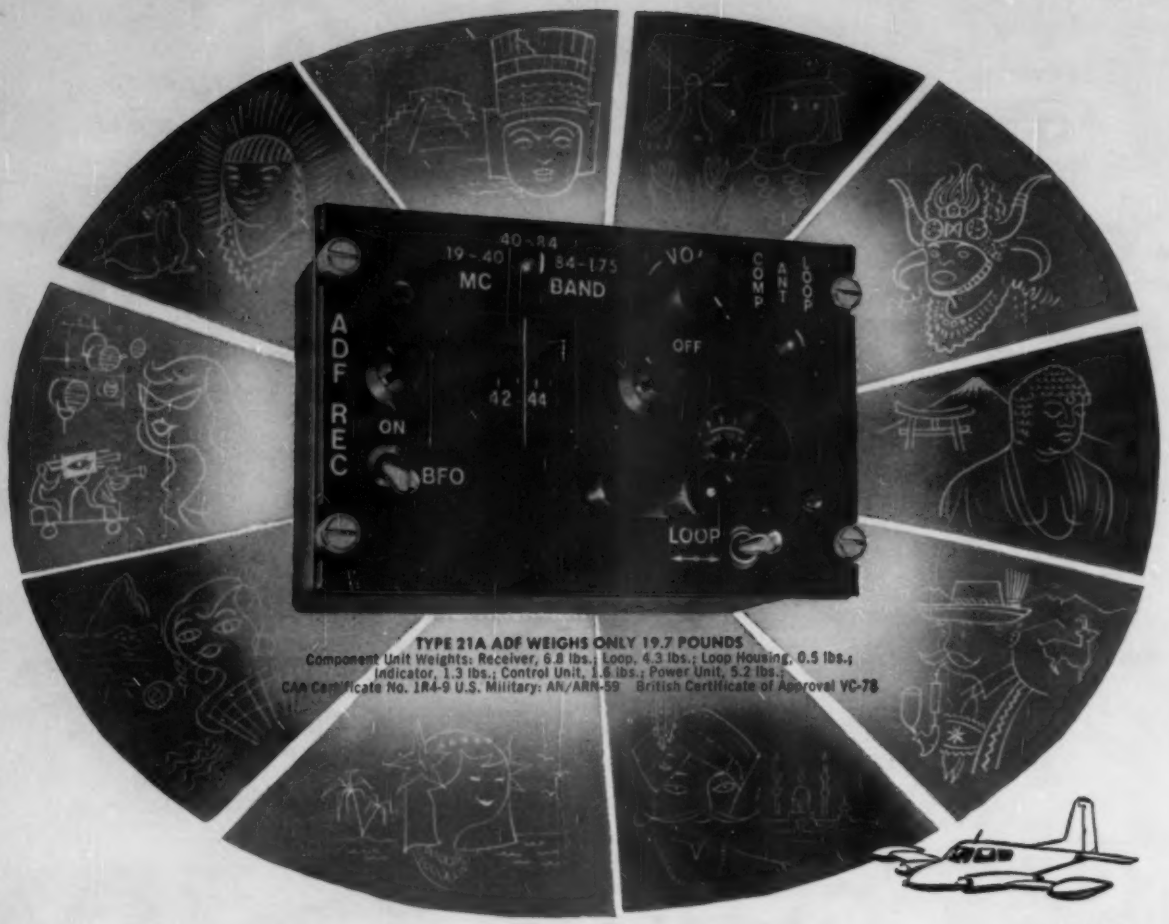

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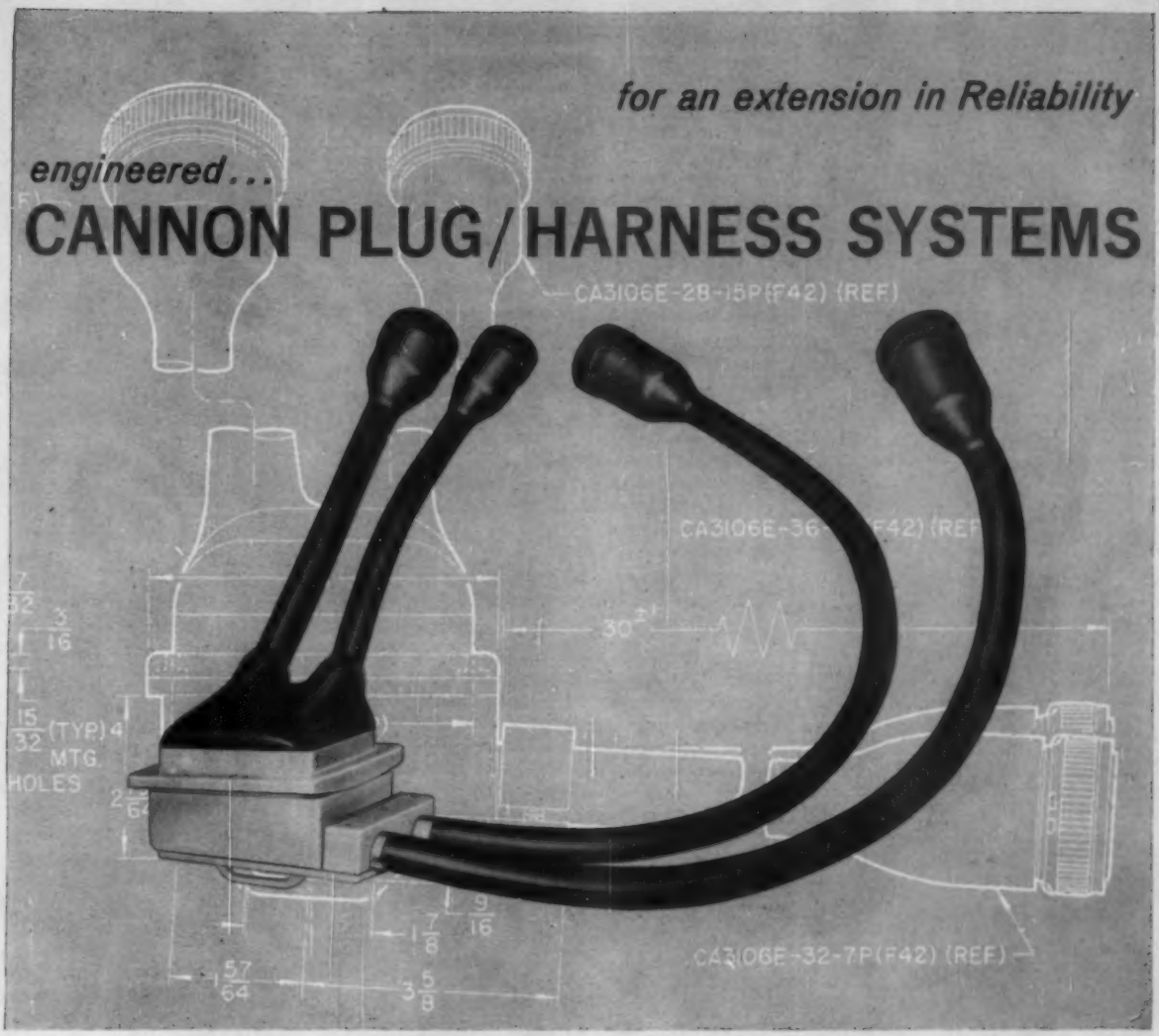

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• FASTER DELIVERY – NO COST PYRAMIDING: A special, separate facility devoted to umbilical and harnessing production offers the most up-to-date production techniques to provide the industry's fastest delivery—plus no pyramiding of costs. Customers draw on Cannon's capabilities as the world's largest exclusive manufacturer of electrical plugs.

• FIELD TECHNICAL ASSISTANCE: Experienced specialized sales engineers are available to discuss and assist customers in the technical aspects of plug-harness system requirements prior to manufacture and after installation in the field.

FOR FURTHER INFORMATION on Cannon Plug/Harness Systems write for Cannon Catalog HC-1— Cannon Electric Company, 3208 Humboldt Street, Los Angeles 31, Calif. Please refer to Department 110.

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Wallingford, Connecticut

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neptune

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stars that fall in the stellar spectral classes B0 through F9 inclusive. The reasons are:

- **Identification.** In the bright stars of spectral classes B0 through F9 the hydrogen gamma line is both well defined and easily identified.
- **Photomultipliers.** The hydrogen gamma line is in the region of the peak wavelength response of low noise and high sensitivity photomultipliers.
- **Stellar energy.** The hydrogen gamma line is in the wavelength region of maximum stellar energy output for stars of these spectral classes.
- **Numbers.** At least 36 of the 50 brightest stars in the sky are included in these spectral classes, and all 36 have a maximum radial velocity with respect to the sun of less than 40 miles per second. (Stellar velocities are related to the sun rather than earth to eliminate the variable factor resulting from the earth's rotation around the sun.)
- **Interference.** The hydrogen gamma line is sufficiently removed from the infrared part of the spectrum so that radiation interference from hot windows, optical components and gases will not interfere with reception of the stellar energy.

Optical System

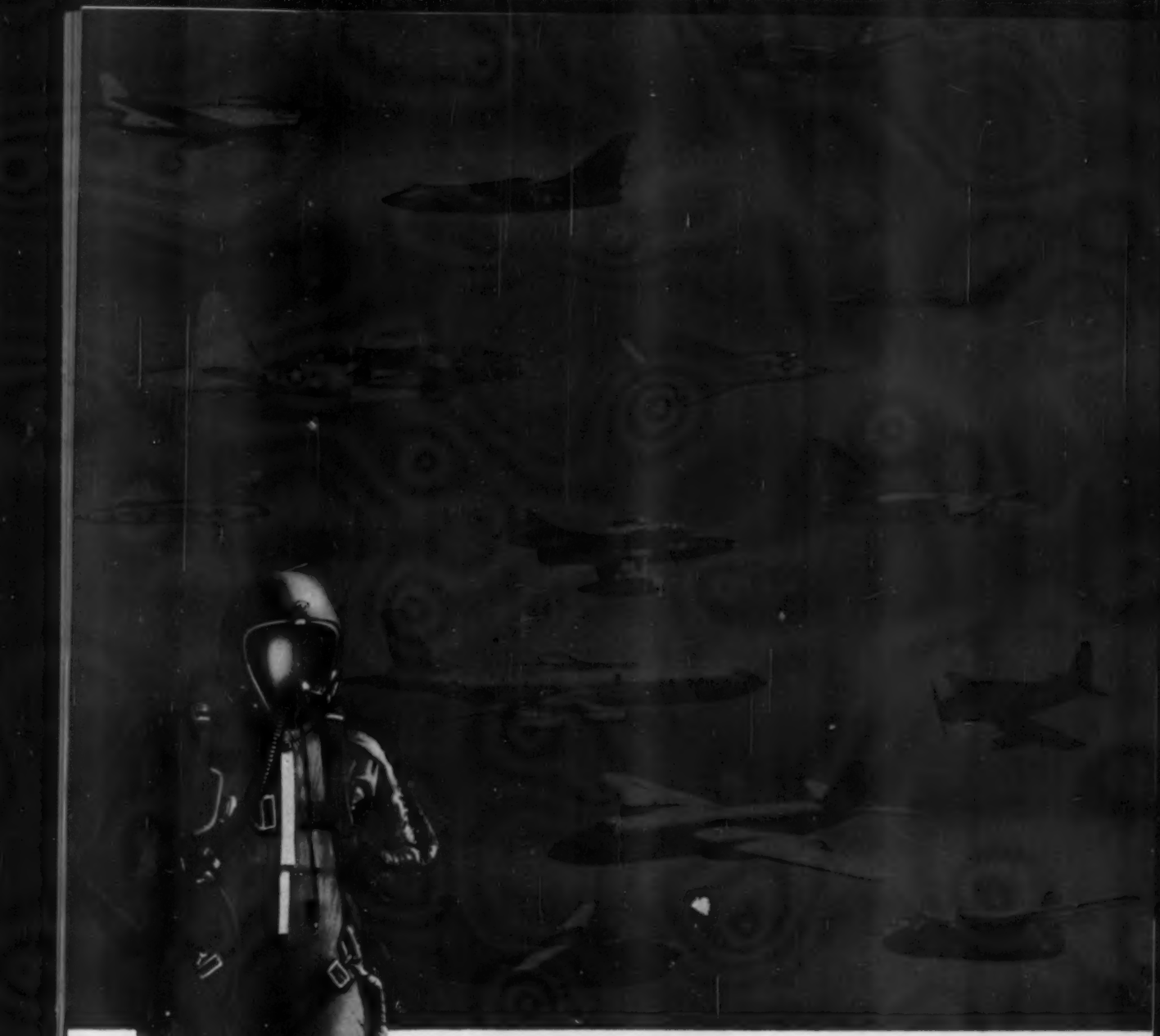
The optical system of the ADDS device is designed so that the stellar light energy is collected by a mirror and directed onto a convex mirror which focuses it onto a light funnel. This makes the collecting system a Cassegrainian-type telescope which provides for off-axis focusing, permitting a more compact internal instrumentation.

The light funnel consists of a group of optical fibers arranged so that the input is clamped in the shape of a circle while the output is in the form of a rectangular slit. This serves two purposes: it provides a relatively efficient method of producing a narrow rectangular slit from a circular stellar image, and it provides compensation for the motion of the stellar image due to errors in the tracking apparatus or to aberration. With this arrangement the stellar image can jitter over a one-half degree angle without interfering with the operation of the system.

The slit at the output of the light funnel forms the input to the spectroscopic system which consists of:

- **Collimating lens** which collimates light from the light funnel slit and directs it onto a diffraction grating.
- **Diffraction grating** which reflects and disperses the light into its various wavelengths, directing the hydrogen gamma wavelength in the direction of a set of three mirrors that focus and reflect it successively. Mirrors form a folded-up optical path 24 in. long.

The diffraction grating is used in a



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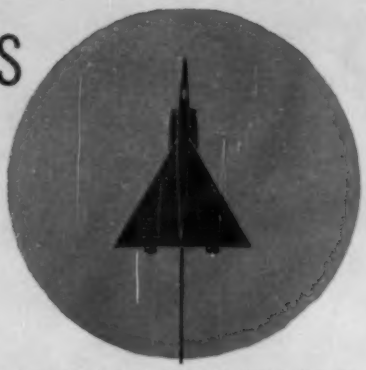

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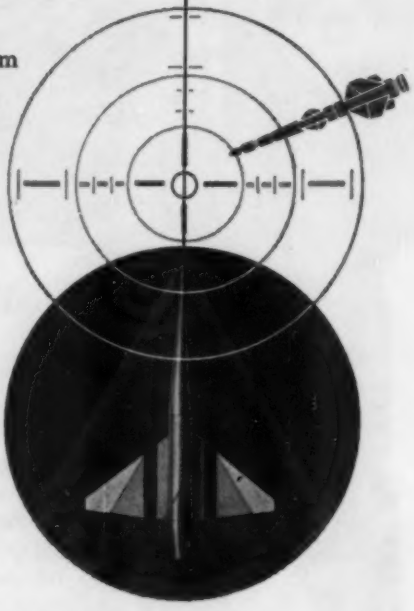
Tomorrow's ground-to-air and air-to-air anti-missile systems will not be effective until crews are trained to use them. For this reason, Del Mar Engineering Laboratories privately supports a dynamic R & D program that will provide realistic training systems concurrently with the delivery of weapons systems that are still under development. By not waiting for an "invitation to bid" on established training system requirements, Del Mar helps to "plug the gap" in America's defense and drastically reduce dangerous lead-time periods.

A product of this farsighted policy is the RADOP® Weapons Training System presently in universal use by the military air services of the United States, Canada, and other NATO countries. This system uses a wood-fiber tow target that costs less than a hundred dollars and is launched and recovered in flight. The remarkable ability of the RADOP® target to "stand in" for high-performance aircraft introduces a higher degree of realism into training than is available with other more costly systems.



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modified Littrow arrangement (which places a lens in front of the grating to provide double-focusing of incident light, both on entry and reflection). The grating contains 600 grooves per millimeter. Operating in the seventh order, it yields a dispersion of 10^{-4} radians per angstrom, and an efficiency of 50%.

The hydrogen gamma wavelength is then directed onto a dividing prism which separates the spectrum into two parts, reflecting each part onto secondary prism mirrors which in turn reflect these parts onto photomultipliers. The light power that each photomultiplier tube receives is its share along the spectral intensity curve of the wavelength portion occupied by the hydrogen gamma line.

This means that one tube receives from 4,330 angstroms to 4,340 angstroms while the other tube receives from 4,340 angstroms to 4,350 angstroms. Wavelengths greater or less than these are not reflected by the prism and therefore are not received by the photomultipliers.

As Doppler shift occurs, the spectral intensity curve will shift. This causes the amount of light energy to be received by the two tubes to become unequal. This inequality is the source of the error signal that controls the servo system.

Servo System

The outputs of the two photomultipliers are coupled in a bridge network, whose output is the difference of the photomultiplier outputs. If there is no Doppler shift, the outputs of the photomultipliers will be equal, and the output of the bridge will be zero.

If, however, a Doppler shift occurs, the output of the bridge will be an error signal which, when amplified and applied to the coil controlling the movement of the capture assembly, will cause the capture assembly, which includes the dividing mirror and the two prism mirrors, to move linearly until the error signal is driven to zero. The amount of this displacement is therefore equal to the Doppler shift of the hydrogen gamma line. A variable capacitor which moves with the capture assembly provides the means by which this displacement is measured.

To provide a means of calibration which will remove the effects of mechanical instabilities and electrical drifts, a calibrating source is located behind the convex mirror of the collecting system. This means that light energy from the calibration source travels the entire optical path from the light funnel to the photomultipliers.

In this manner, the complete optical system as well as the servo system, the capture assembly displacement and the photomultipliers can be calibrated si-

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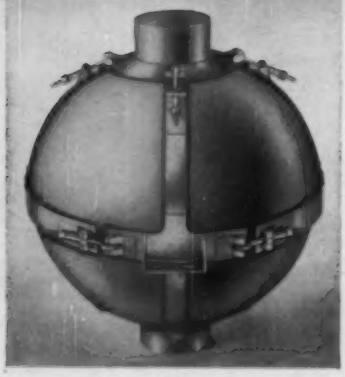

Awica Division: Awica clamps and couplings in complete range of shapes and sizes for a variety of uses provide positive fastening for fluid and electronic systems. Patented Hook-Bolt design is a superior feature of Awica clamps.

U.S. Propellers, Inc.: Produced contra-rotating ducted propellers for this Hiller machine. U.S. Propellers designs and manufactures fixed and constant speed propellers, ducted fans, helicopter blades, wind tunnel and air movement systems.

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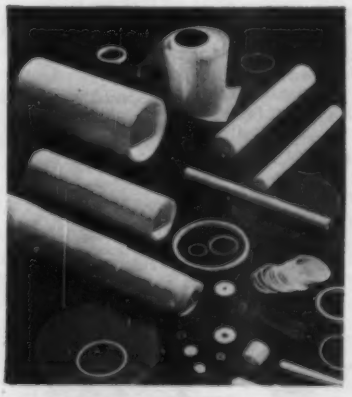

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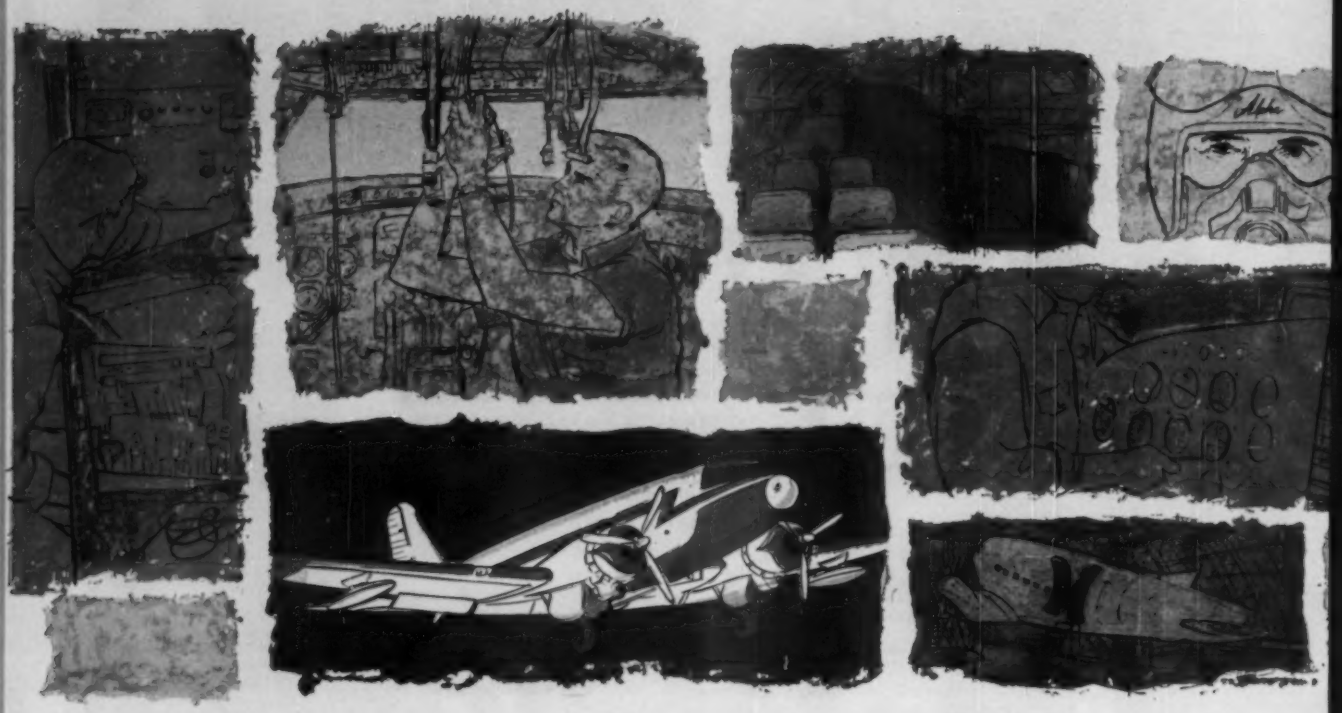

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A notable example in the aircraft modification field is "Project Shirley" . . . a contract awarded Collins Radio Company by the United States Army Signal Corps. Starting with six surplus R4D aircraft (Navy versions of DC-3's) the airframes were reconstructed to meet exacting requirements imposed by the installation of extra complex electronic assemblies. Further, interiors were redesigned for extreme flexibility . . . including accommodation of seating or extensive airborne test equipment. These versatile "flying laboratories" exemplify the kind of complete, turnkey jobs Alpha handles at its Air Modification Center. Further, Alpha fabricates specialized equipment and installs it on client aircraft all over the free world.

Alpha was formed to extend and broaden the types of systems management work done for years by Collins Radio Company. This includes design, engineering and installation of space age communication systems complete with related roads, buildings and towers. The best available equipment from industry is used. Alpha trains client personnel or furnishes skilled crews for finished projects where needed.

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Infrared Cooler

Closed-cycle helium refrigeration device increases the sensitivity of infrared detectors by cooling them to 60K (—350F). The 8 oz. component, called min-IR-cooler, expands helium from 300 psi. in a ¼ in. diameter cylinder 2 in. long. Cold infrared detectors are sensitive to wider ranges of infrared wave lengths. Cooling unit was developed by Arthur D. Little, Inc., and is produced under license by Hamilton Standard Division of United Aircraft.

multaneously. The calibration source consists of a lamp surrounded by an element or compound that absorbs wavelengths about 4,340 angstroms so that the combination of the lamp and element yields an absorption line at the wavelength of the hydrogen gamma line. Periodic calibration would be provided at the rate of once per second.

Linear Displacement

The measurement of the linear displacement of the capture assembly is provided by the variable capacitor. The variable plate moves relative to the fixed plates when the capture assembly is displaced which produces a push-pull change in capacitance that is used as a vernier to vary the resonant frequencies of two oscillators. The difference of the change of frequencies of the two oscillators is proportional to the linear displacement of the capture assembly and therefore to velocity. The oscillator output frequencies are converted to a digital output by an up-down counter. A clock switch is used to synchronize and control the inputs to the velocity counter. These inputs are controlled in a serial fashion, and are synchronized with the calibration source.

The accuracy of velocity measurement depends upon the ability of the system to maintain and measure the shift of the hydrogen gamma line. This

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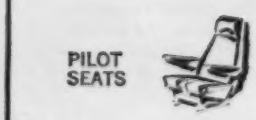

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in turn depends upon the ratio of Doppler signal-to-system noise. The Doppler signal is a function of the energy from the star collected by the telescope, and the attenuation of this energy by the optical and spectrographic elements.

The system noise is a function of the noise generated by the photomultipliers and their associated circuits, and the amount of integration incorporated into the system. By far the greatest source of error is that caused by photomultiplier noise which limits the resolution of the servo system to some equivalent value of velocity. This noise is reduced by the use of Peltier crystals which cool the photocathode to −20C, and by reducing the signal bandwidth to one cycle per second.

Calculating on the basis of a signal-to-noise ratio of three and a velocity information rate of one cycle per second, the star Sirius yields an accuracy of 0.008 miles per second, or 42 fps. This accuracy could be further improved if a longer integration time were made available by using a lower information rate.

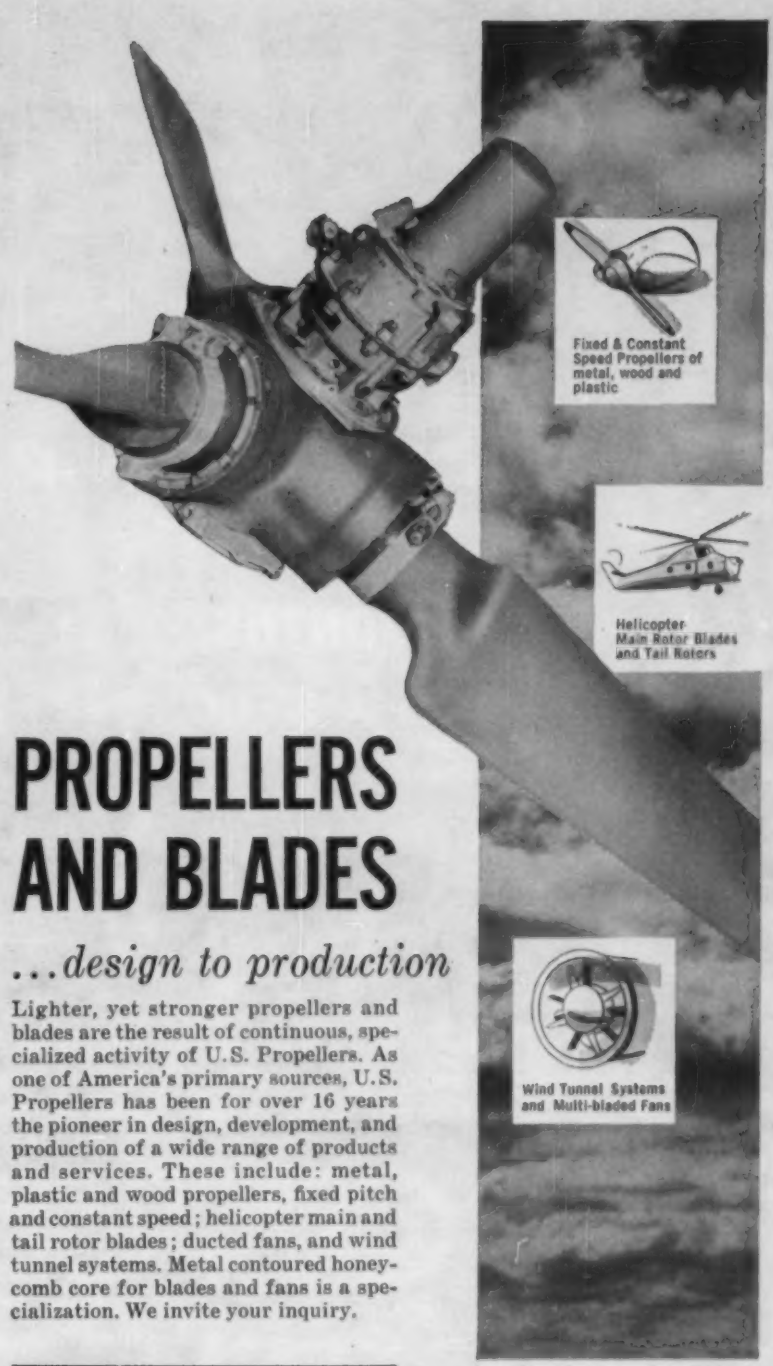
Photographic Plates Show Radiation Peak

Berkeley, Calif.—Peak radiation intensity of the inner Van Allen radiation belt has been estimated at approximately 100 roentgens per hour—a level that could kill a human after four hours exposure—based upon analysis of photographic plates carried aboard Thor-Able nose cone recovery last month.

Photographic plates carried in the nose cone, which reached an altitude of 770 mi., appear to confirm the earlier theory that the inner belt consists predominantly of high-energy protons produced by cosmic ray bombardment of the earth's atmosphere, according to Dr. R. Stephen White and Dr. Stanley C. Freden at the University of California Radiation Laboratory.

Peak radiation intensity encountered at an altitude of 770 mi. was one roentgen per hour. Extrapolating to an altitude of 2,000 mi., the peak radiation region of the inner Van Allen belt established by earlier space and satellite experiments, led the University of California scientists to their 100 roentgen per hour prediction. However, they point out that one inch of lead shielding could reduce radiation intensity for space vehicle passengers by 90% and that 6 in. would reduce the level by 99%.

Analysis of the photograhic plates indicates that about 1% of the protons in the inner belt have an energy of 700 million electron volts, about 10% have energies of at least 300 million electron volts, and the remainder have energies down to 75 million electron volts.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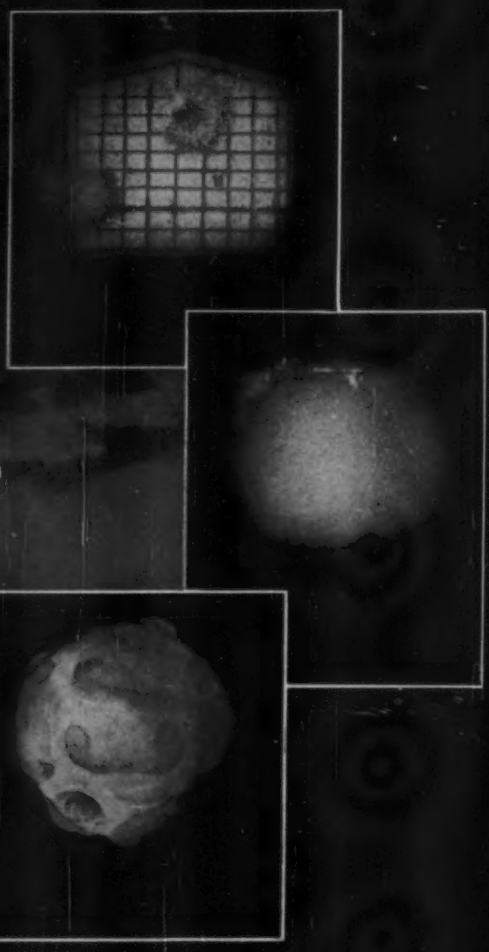

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FILTER CENTER

▶ **"Wear-less" Gyro Bearings**—Joint research program by Sperry Gyroscope Co. and Alloyd Research Corp., Watertown, Mass., has uncovered cause of gyro bearing wear which causes drift and breakdown, Sperry says. Company reports that it has discovered microscopic residual abrasive particles were imbedded in ball bearings and races when produced by conventional processes. Using a newly developed technique to minimize such particles, Sperry says it has tested gyros for several thousand hours with no sign of bearing wear.

▶ **RCA Digs Into Earth Currents**—Radio Corp. of America is investigating transmission of electromagnetic waves through the earth, possibly for use in tieing in Arctic Ballistic Missile Early Warning System (BMEWS) to U. S. Air Defense Command headquarters.

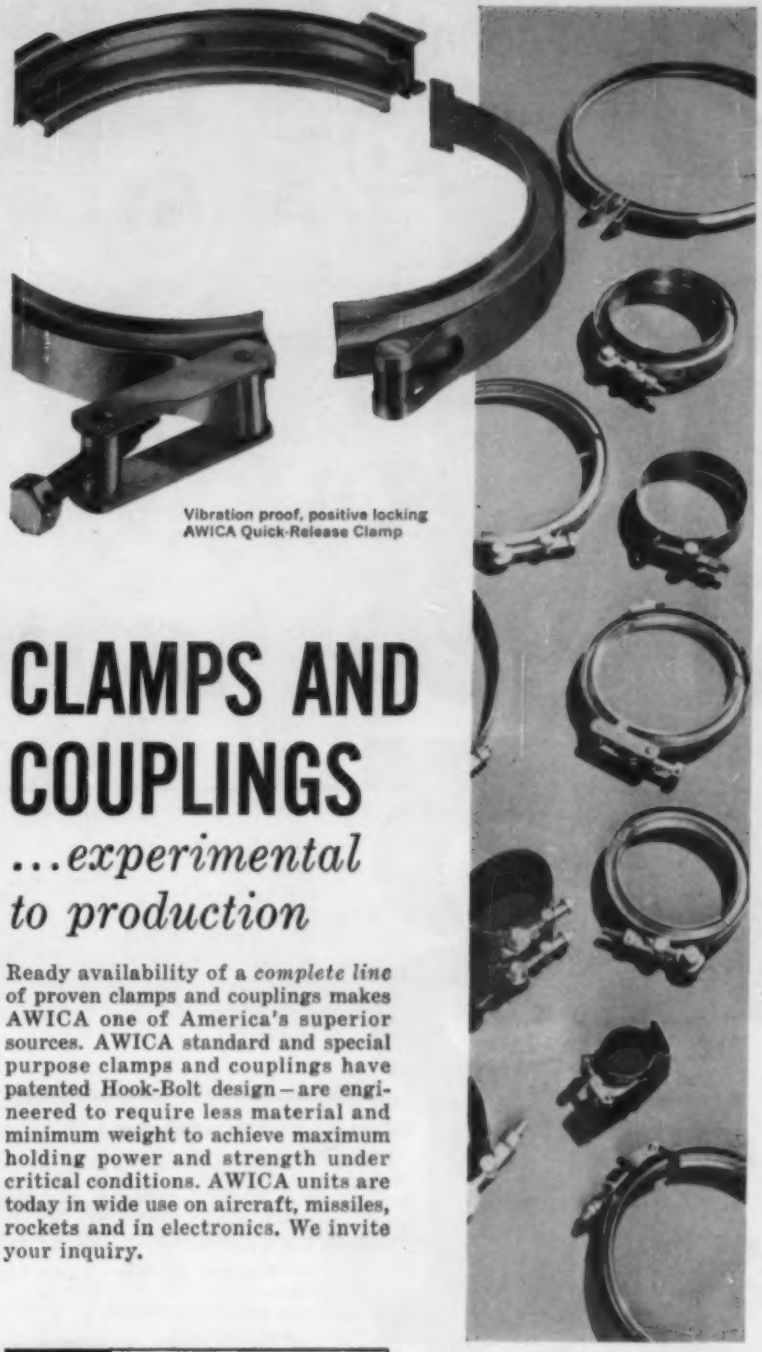
▶ **Litton Guidance for F-104D**—Lockheed F-104D, which has been purchased by West German air force, will be outfitted with lightweight pure-inertial navigation system developed by Litton Industries. Aircraft also will use monopulse radar, originally developed by North American's Autonetics Division for the Republic F-105.

▶ **Silicon vs. Germanium Transistors**—One out of every four transistors sold in 1962 is expected to be made of silicon as compared with only one out of 20 during 1957, according to a market survey of design engineers made by Hoffman Electronics Corp. Two biggest problems now encountered with silicon transistors are high saturation resistance and wide variation of parameters, survey disclosed.

▶ **Inertial Guidance Made Easy**—Simplified description of principles of inertial guidance in pocket size 16-page booklet with reading time of about five minutes has been prepared by Sperry Gyroscope Co.

▶ **High Temperature Capacitors**—Report on investigation of two dielectric materials, magnesium oxide and aluminum oxide, which have insulation resistances high enough for use in capacitors intended for operation at temperature of 50C under nuclear radiation is available from Office of Technical Services, Commerce Department, Washington 25, D. C. The 81-page report, identified PB 151256, is priced at $2.25.

▶ **Signed on Dotted Line**—Major contracts recently announced by avionics



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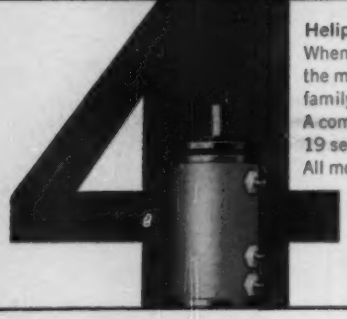

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manufacturers include the following:

Ballistic Missile Center has awarded four contracts, totaling $63 million, to the Defense Systems Department of General Electric Co. for development and testing of radio command guidance systems for Atlas ICBM.

• **Wilcox Electric** reports orders for 26 additional 714B air traffic control transponders from Pan American for use on its jet transports, bringing the total PAA order to 58.

• **Collins Radio** reports a $750,000 order from American Airlines for glide slope receivers, omnirange receivers, ATC transponders and automatic direction finders for use on its fleet of Boeing 707s and Convair 600s.

• **Ryan Aeronautical Co.,** Electronics Division, $1.25 million award from Sikorsky Aircraft for additional quantity of AN/APN-97 Doppler radar navigation systems for use in HSS-1N helicopters and a number of systems for installation in British Navy anti-submarine warfare helicopters being produced under Sikorsky license by Westland Aircraft, Ltd.

• **Sperry Gyroscope Co.,** initial order totaling $1 million from Lockheed, for lightweight SP-40 autopilot for use on company's 10-passenger JetStar transport. New SP-40 autopilot weighs only 80 lb., provide automatic approach and VOR-beam riding capabilities.

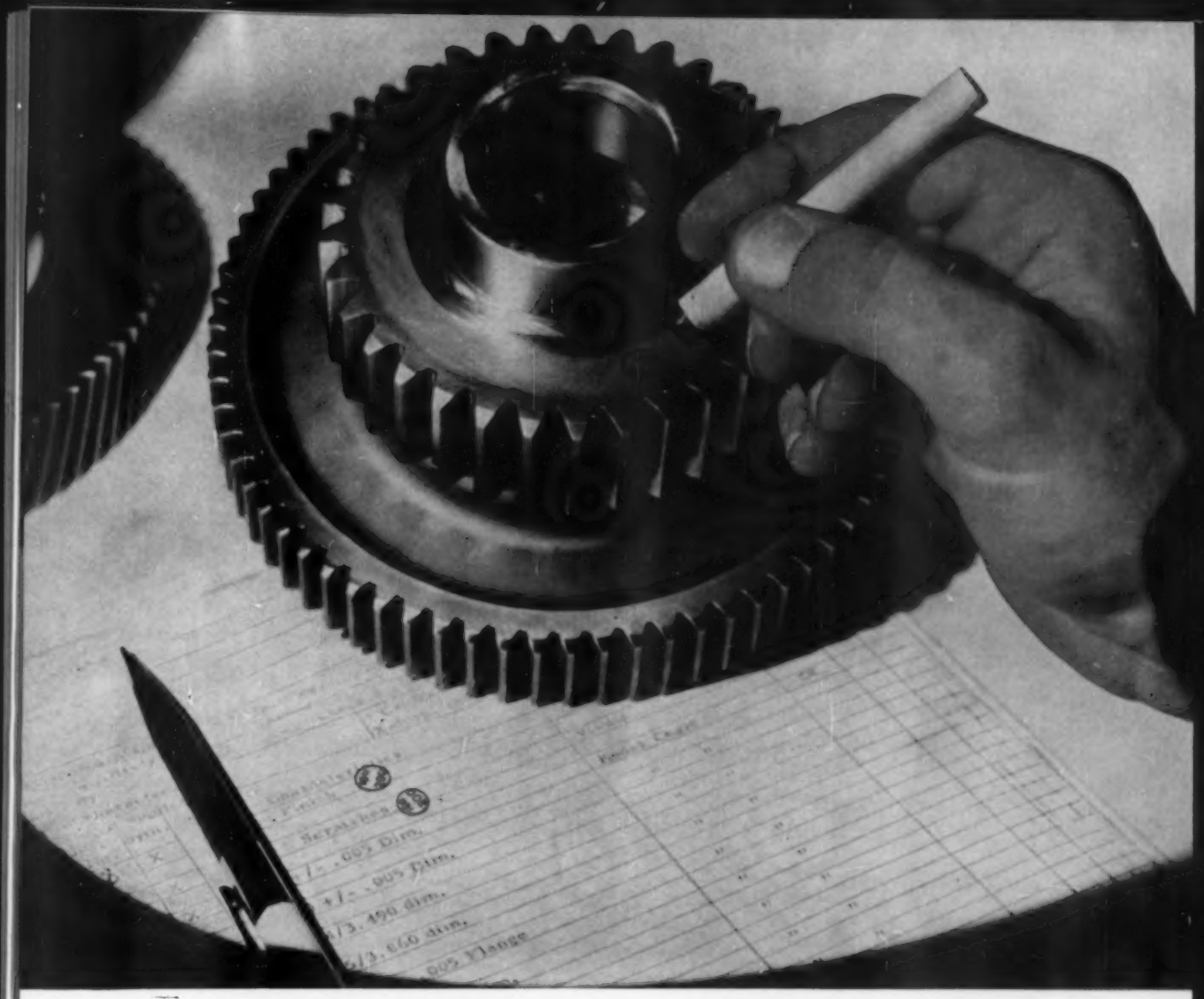
• **Goodyear Aircraft Corp.,** Litchfield Park, Ariz., reports contract from Army Engineer Research and Development Laboratories, for research on an advanced radar mapping system.

• **National Cash Register Co.,** Electronics Division, Hawthorne, Calif., a $90,000 contract from Wright Air Development Center for research in photochromic memory devices for ultra-high-density computer storage systems. Technique is based upon use of light-sensitive liquid dye stored in tiny gelatin capsule. Up to 1,000,000 such capsules can be placed on square inch of film.

• **Perkin-Elmer Corp.,** Norwalk, Conn., $94,000 contract from Princeton University for a 36-in. aperture telescope to be used in high altitude unmanned balloon for photographing planets and other celestial bodies. Funds for project are being provided by National Science Foundation and Office of Naval Research.

• **Epsco-West,** Anaheim, Calif., contract for more than $200,000 from Convair for equipment to time and monitor subsequential operation of 50 microswitches in controlled automatic programed checkout equipment (CAPCHE) for Atlas ICBM.

• **Convair,** San Diego, a contract for $2,283,120 for design, construction and installation of automatic data handling system to be used at Wright Air Development Center.



The compound gear you see here is probably the finest example of precision rocket power gearing ever produced. It gears the turbo-pump in a Rocketdyne liquid propellant rocket engine. Tooth-to-tooth spacing is a maximum of three ten-thousandths, a tolerance on the smaller gear that can't be met with conventional grinding equipment. This gear delivers more than 3000 horsepower and turns from zero to over 10,000 rpm in less than a half-second. Only the finest precision equipment and craftsmanship can produce a gear to such rigid specifications. It is one more example of "precision" at I.G.W

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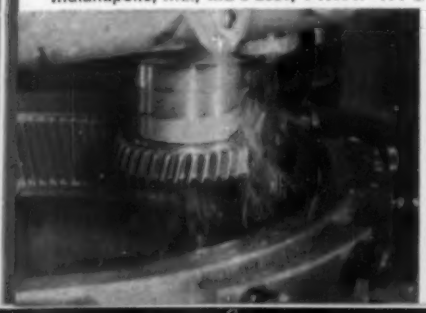

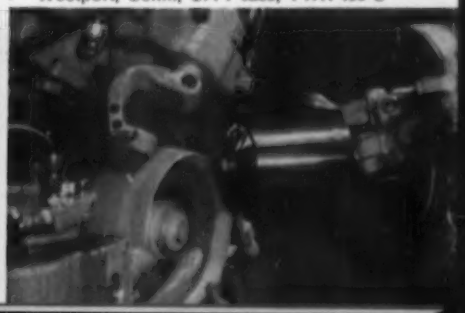

POLARIS FBM

DISCOVERER SATELLITE

PROJECT ARG

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EXPANDING THE FRONTIERS OF SPACE TECHNOLOGY

■

ADVANCED PROJECTS AT LOCKHEED

DISCOVERER SATELLITE—Designed and built by Lockheed Missiles and Space Division, the first of a series of DISCOVERER satellite launchings was successfully placed in orbit on February 28. Later satellites in the series will carry live animals and their recovery attempted. Valuable data will be obtained on space environment and recovery techniques of major importance to the nation's space program. The DISCOVERER is an Advanced Research Projects Agency program under the direction of the Air Force Ballistic Missile Division, with Lockheed as systems manager.

POLARIS FBM—Lockheed is missile systems manager for the Navy POLARIS Fleet Ballistic Missile, under the cognizance of the Special Projects Office of the Bureau of Ordnance. Submarine-launched, the POLARIS will travel through three mediums in a single flight: water, air and outer space. With three-quarters of the earth's surface being water, practically no target in the world is outside its range. The solid-propellant POLARIS was *designed with the future in mind*—an approach that the Navy states has cut nearly two years from the original timetable.

Q-5, KINGFISHER—Developed for the Air Force, and currently being manufactured for the Army, the Kingfisher is designed to simulate enemy attacks to test the efficiency of our various defensive weapon systems. It is equipped with extensive instrumentation to register "kills" without itself being destroyed and can be recovered by parachute and landing spike to be used again, with marked savings in cost.

X-7—Lockheed's X-7 recoverable ramjet-engine test vehicle, developed for the Air Force, has established speed and altitude records for air-breathing vehicles and is also recoverable for re-use following flight.

X-17—The nation's first successful reentry tests were conducted by the Air Force with the three-stage, Lockheed X-17 solid-propellant ballistic missile. The X-17 has pioneered many new techniques and the valuable experience gained from this program has facilitated development of other, inter-service projects, including the Navy POLARIS FBM. The Navy's history-making, 300-mile-high, Project Argus radiation explosions featured the X-17 as the vehicle.

SPACE STATION—An orbiting research facility, to serve as an advance base for space exploration, has been proposed in practical detail by Lockheed's research and development staff. The station would carry a 10-man crew. Prefabricated compartments for the rim of the wheel, the spokes, and the three hubs would be launched separately by means of ballistic missiles and guided into a cluster on the same orbit.

The successful completion of projects such as these requires a bold and imaginative approach to entirely new environments. Lockheed's programs reach far into the future. It is a rewarding future which scientists and engineers of outstanding talent and inquiring mind are invited to share. Write: Research and Development Staff, F-17, 962 W. El Camino Real, Sunnyvale, California. U.S. citizenship required.

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Stirling Engine Studied for Satellite Use

By Michael Yaffee

Indianapolis—A 143-year old engine that once pushed river boats up and down the Mississippi River has been rescued from obscurity and may prove the key to efficient, lightweight, long-lived satellite auxiliary power units. Designated the Stirling engine, after the Scotsman who invented it, the unit can operate on almost any primary energy source and will develop any amount of electrical power to 100 kw.

One of the first airborne applications of the Stirling engine may be in the SNAP I nuclear auxiliary power system now under development at the Martin Co. Present plans call for this system to use a mercury engine, operating on energy from radioisotopes, to drive a turbogenerator. But this program reportedly is having trouble finding materials that will function properly in a mercury environment and it is expected to be another year or year and a half before the first Rankine cycle mercury engine is ready. The Stirling engine, according to Allison Division of General Motors, could be produced now.

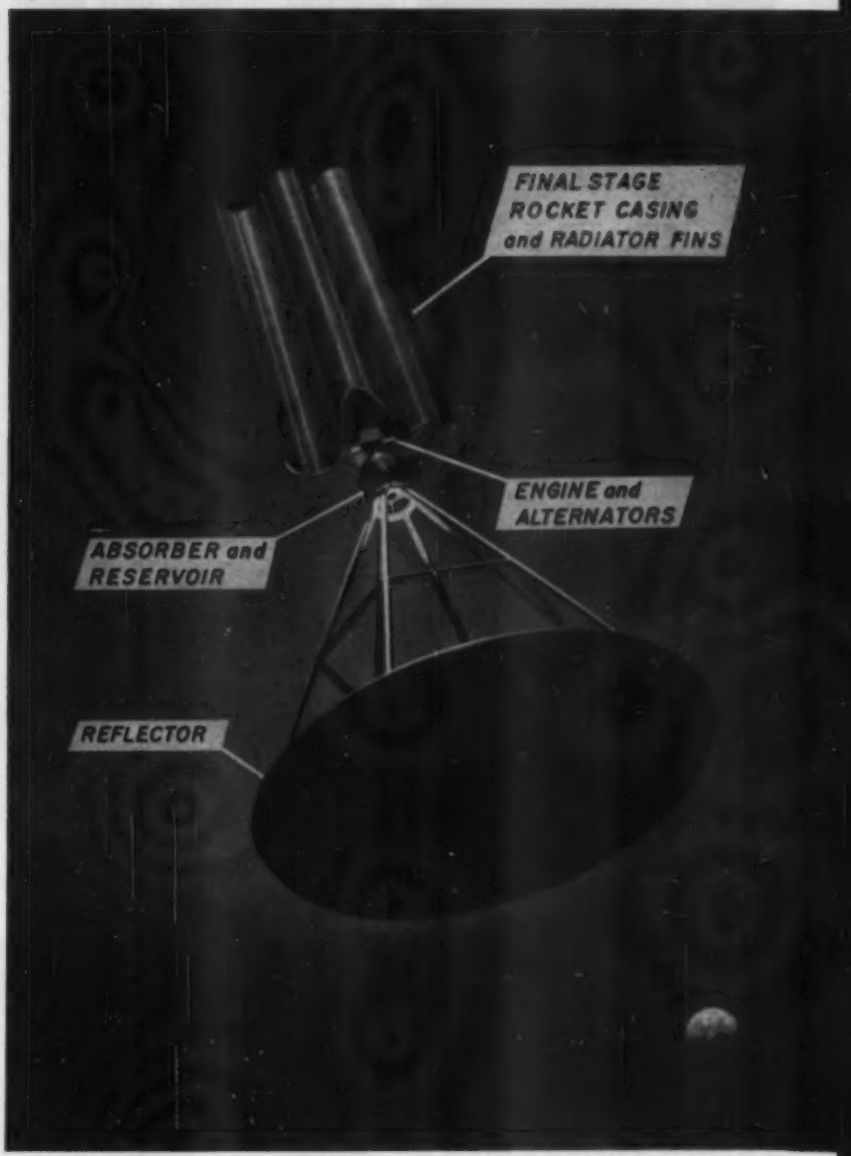
There are, of course, a number of other power systems, e.g., chemical batteries or thermionic converters, that can be used to produce electricity. Some of these systems are now being used; others are in development or are being studied under sponsorship of the Atomic Energy Commission and/or the different military services. But where a few kilowatts or more of electrical power are required now, Allison says the best bet appears to be a mechanical system in which a mercury or Stirling engine is used to drive an electric generator.

The present advanced Stirling engine is a far cry from the early models which had thermal efficiencies of only 5-10%. These early engines were soon replaced by the more efficient steam engine and, somewhat later, by the Otto and Diesel engines. Although the Stirlings were improved from time to time, it was not until 1954 that new advances in thermodynamics and mathematical analysis made it possible to produce a Stirling engine with a 36% thermal efficiency—an efficiency comparable to that of the Diesel and superior to that of the Otto.

Subsequent improvements in the regenerator (which was not part of the original Stirling engine) increased the efficiency even further and, along with the other advantages such as its closed cycle operation, aroused Allison's interest in the Stirling for possible application as a satellite auxiliary powerplant.

The efficiency of the mechanical system is far superior to that of the others, particularly where the power requirements are more than 15-20 kw. In the case of the Stirling engine, the efficiency of the engine has now been raised to a demonstrated level of 39%, according to Allison, which is modifying the unit under foreign license for satellite and ground power applications. The greatest efficiency achieved by any engine is approximately 42% obtained in an operating steam plant.

Since its only energy requirement is



IN SOLAR-POWERED satellite auxiliary power system, reflector focuses sun on absorber, where heat is picked up by liquid metal and carried to Stirling engine which converts it by means of a generator to electricity.

Vital to the wondrous advancement of our rockets, missiles, and jets are the grueling tests and checkout of their components on high speed test stands that simulate actual operating conditions during flight. Today, major test installations are equipped with S-N High Speed Gear Increaser Units. Most jets have components checked on S-N equipped high speed test stands.

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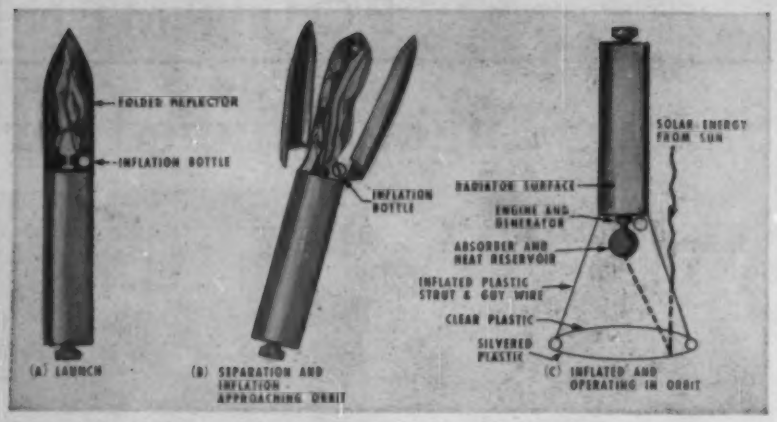


AT LAUNCH, solar-powered Stirling auxiliary power unit is covered by protective cone which is later blown away to allow for inflation of reflector.

heat, the Stirling engine will operate on any heat source from Bunker C oil to solar rays. For longtime space applications, the primary energy source narrows down to either the sun or a nuclear reactor. Although heavier, the reactor would make possible a more compact power source. Solar energy, however, has the advantage of being more readily obtainable.

Other Advantages

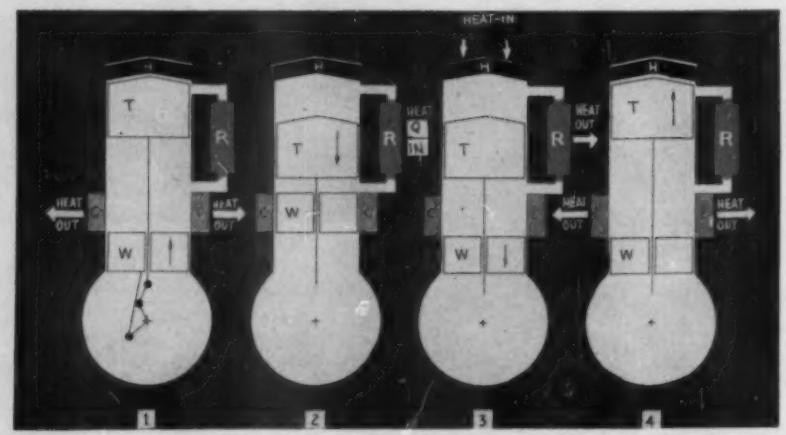
Other advantages claimed for the advanced Stirling engine include:

- **Long life.** It is believed that this engine will meet the requirement for a two year operating life, desired by the military.
- **Closed cycle operation.** Working fluid is sealed in, eliminating possibilities of contamination or oxidation.
- **High reliability.** There are no valves and operating temperatures are low.
- **Wide choice of working fluid.** Any gas can be used; Allison plans to use helium.
- **Very low noise.** This characteristic is of particular importance to portable military ground power units.
- **Moderate weight.** The Stirling engine, Allison says, is only about one-third as heavy as a comparable mercury unit.

A fairly important disadvantage of the Stirling engine, according to a Navy officer working in the nuclear auxiliary power program, is its need for lubrication. Assuming that the engine will be operating on nuclear energy, he points out that most lubricants quickly deteriorate under radiation. This problem, however, may be solved as a result of the extensive programs already under way to develop radiation resistant lubricants.

Engine Vibration

Another problem and point of controversy concerning the Stirling engine is the matter of vibration, which some engineers feel is a serious drawback to the unit, especially in satellite applica-



FOUR STEPS in the Stirling cycle, as depicted in diagrams, show position of displacer (T) and work (W) pistons during (1) isothermal compression, (2) constant-volume heat addition, (3) isothermal expansion and (4) constant-volume heat rejection. Heat is added through the head (H) of the engine.

Eyeful of Future

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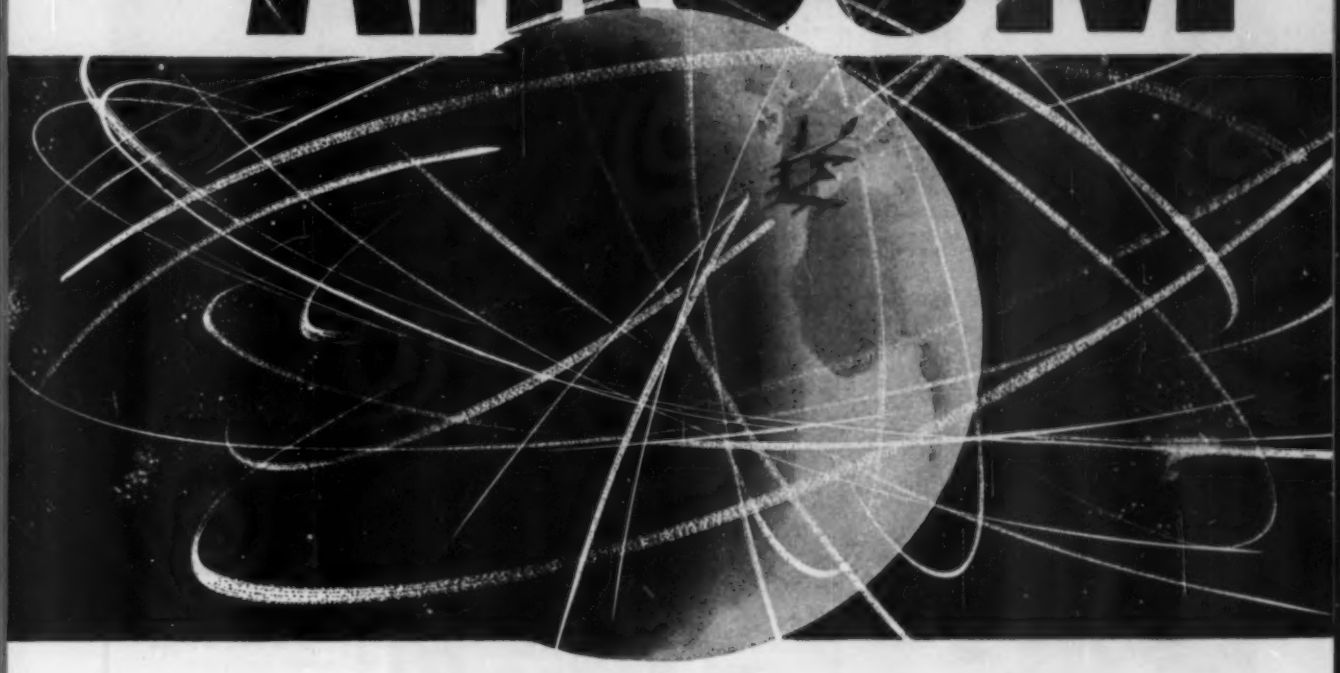

A program is under way to design the world-wide communications of the U. S. Air Force to meet growing space-age requirements. This important project takes into consideration the total Air Force communication needs through 1970 and beyond and will provide a plan for the continuing modernization of the network of wires and radio that links strategic bombers, defense warning stations, weather forecasters and other operations throughout the world. Operating as a partner with International Telephone and Telegraph Corporation (the prime contractor), RCA is initiating design and development of a new Air Force Communications System as part of a modernization program for the Air Force and at the same time is assuring coordination and integration with Army and Navy plans.

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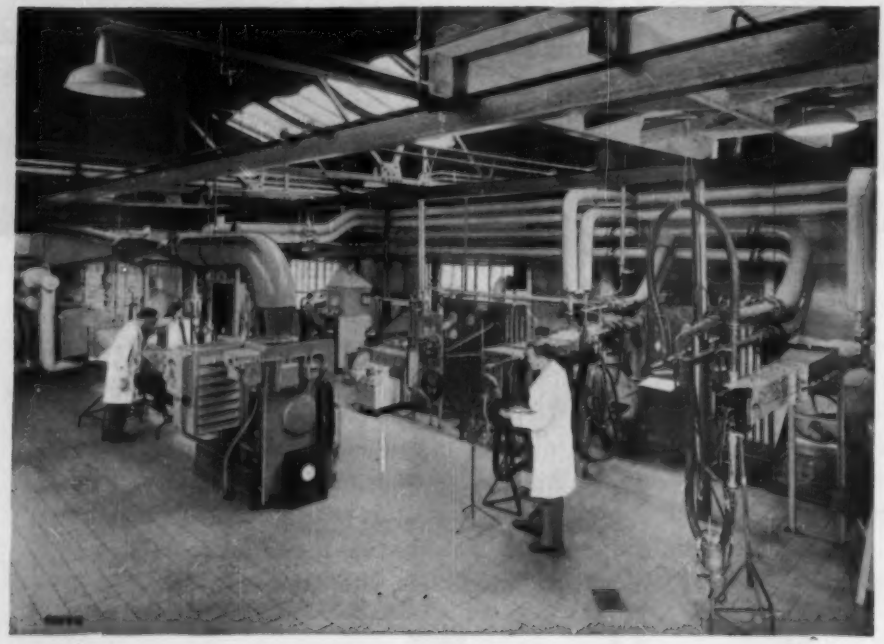

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GYRO PLATFORM keeps satellite oriented so as to obtain maximum solar reflection.

tions. Allison claims the advanced Stirling engine has no inherent vibration normally associated with a reciprocating engine; that all torsionals and shaking forces can be dynamically balanced.

Essentially, the Stirling engine consists of two pistons, working fluid, heater, regenerator, and cooler. Top piston is the displacer piston; bottom one is the work piston, and between the two is the working fluid. The Stirling cycle is a four step gas cycle. In the first step, compression, the displacer piston remains in its uppermost position.

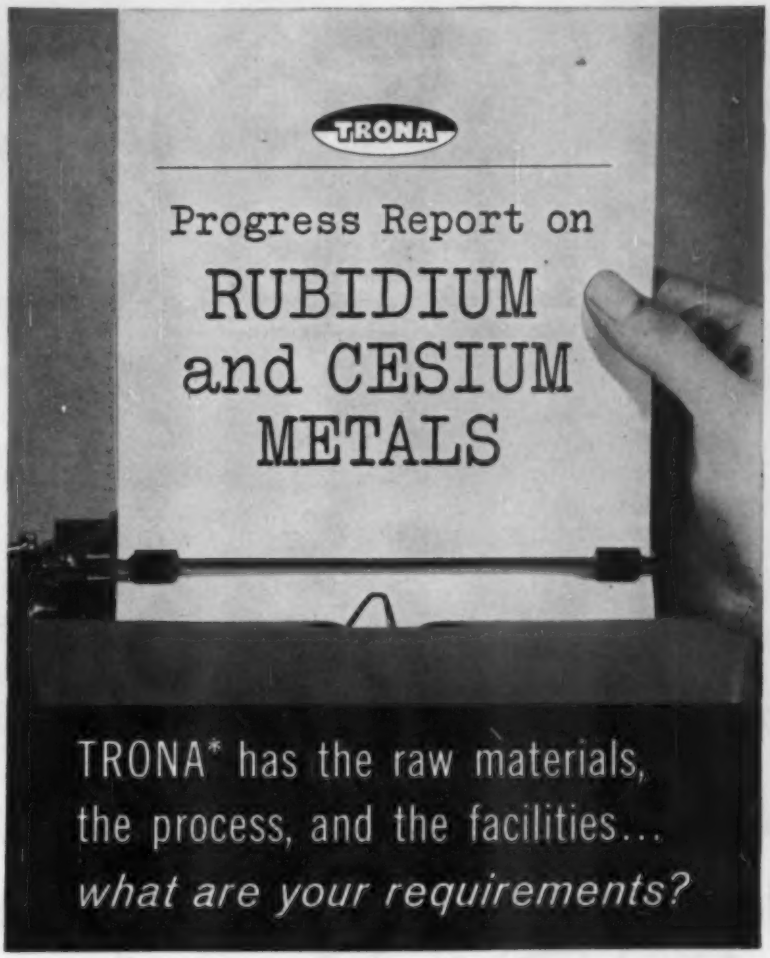
The work piston moves up and compresses the gas. Heat is removed by the cooling unit to maintain a constant temperature.

Second step in the Stirling cycle is constant-volume heat addition. At the end of its upward stroke, the work piston remains at top center and the displacer piston moves down. The compressed gas is thus forced up through the regenerator where it picks up the waste heat which was stored there.

In the third step, isothermal expansion, the displacer piston remains in its lower position and the work piston moves downward to its original position. Heat is added through the head of the engine chamber at a rate adequate to maintain a constant temperature.

The fourth and last step in the cycle is constant-volume heat rejection. This displacer piston moves upward to its original position, forcing the working fluid, between it and the head of the chamber, back through the regenerator (where it stores its waste heat) into the chamber area between the two pistons.

In a solar-powered application, as envisioned by Allison engineers, the advanced Stirling engine would use a metallized plastic reflector to collect the sun's rays and would employ the empty, last stage rocket casing as a radiating



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If your interest is in long-duration secondary power systems for space vehicles, rubidium metal has been proposed as the working fluid in vapor turbines, whether the energy source is nuclear or solar. The properties of cesium metal have led to investigation of its uses in ion propulsion rockets, and in the direct conversion of nuclear heat into electrical energy. As catalysts, or catalyst promoters, rubidium and cesium may have unusual stereospecific properties. In these, or other applications, the availability of Rb and Cs metals and salts from Trona—in volume and at realistic prices—might provide you with an important break-through.

Consult with Trona's technical staff on your investigative needs. Technical literature available on request.

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surface. Briefly, this is how the operation may work:

At launching, the reflector, designed as an inflatable structure, would be folded down over the Stirling engine inside the nose cone of the last stage rocket. (Allison also has designs for somewhat heavier rigid reflectors.) After the two-piece nose cone is blown off and as the satellite goes into orbit, the plastic reflector is inflated from a small gas container.

Small auxiliary rockets position the satellite initially so that the gold reflecting surface, which is attached to the satellite by inflated struts and guy wires, can pick up the maximum number of solar rays. A gyro-stabilized platform then keeps the assembly properly oriented. Should the unit get out of position in respect to the sun, sensors will signal electric actuators which will push against the gyro platform. Some day, Allison engineers, say, gravity differential and light forces may also be used to position the unit. A nuclear reactor, of course, would eliminate this particular problem altogether.

Heat Absorber

From the reflector, the solar rays are focused on a heat absorber and reservoir unit. Lithium hydride is used in the absorber to collect and store the heat. When the sun's rays are focused on the lithium hydride, it melts, absorbing the heat. Then, in the shade, it freezes again and releases the stored heat.

From the lithium hydride reservoir, the heat is transfered to the advanced Stirling engine by a liquid metal which is pumped through a completely closed heat exchanger system. In the engine, the heat is converted to mechanical energy which drives a generator that, in turn, produces the required electrical energy.

Excess heat is removed from the Stirling engine by water flowing through a cooling jacket around the unit. Like the heating system, the cooling system is another closed loop. The water is pumped through the cooling jacket, through a series of tubes in the radiator structure, and then back to the cooling jacket. For one version of the radiator structure, Allison has designed a semi-tubular aluminum fin, two of which would be attached to the final stage rocket casing. The water passages would run longitudinally up and down the fins and casing.

Development of the advanced Stirling engine so far has been a company-funded project. In the last few months, however, Allison has been discussing the project with officials of Advanced Research Projects Agency, National Aeronautics and Space Administration, the military services and the aviation industry. Allison says there has been considerable interest shown.

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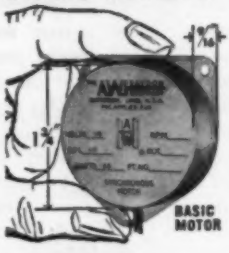
ANOTHER FIRST . . .



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BASIC MOTOR
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Speed: 300 RPM
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Weight: 5 ounces
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Torque: 30 oz.-in. @ 1 RPM
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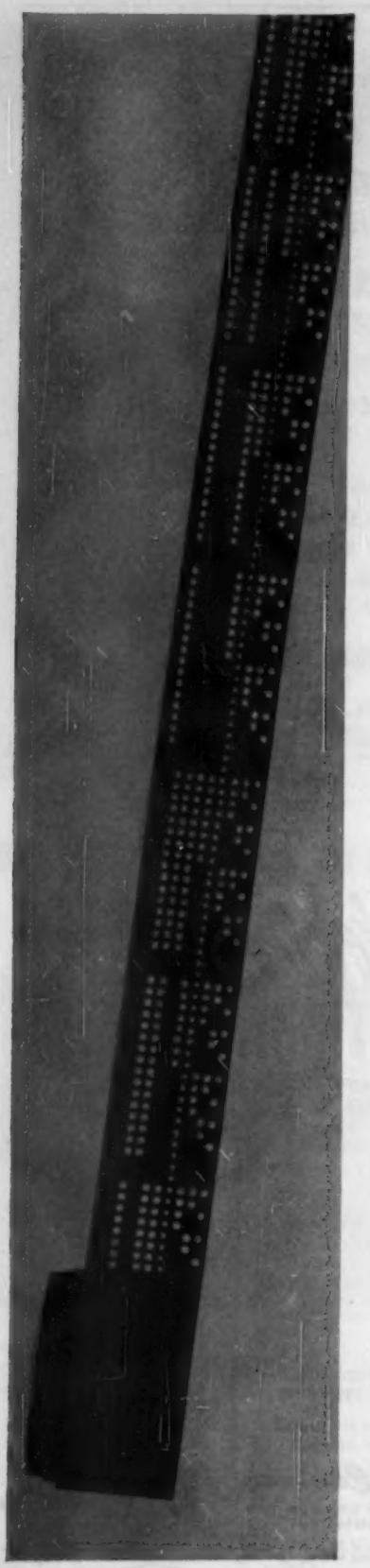

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Honeywell's Compact Random Access Programmer, using solid state switching techniques, makes checkout and countdown fast, accurate, reliable.

When a production missile goes to the field it has to be ready—all the time.

The crew must know, first, that each system, subsystem and component crammed into the missile works perfectly; second, that after launching each will function in a precisely predetermined sequence.

This demands highly accurate surveillance and constant checks, achieved with an absolute minimum of equipment and personnel.

Programming and checkout equipment now being used is for the most part expensive and inflexible, with a low reliability factor. Logistics of coordination are puzzling and uncertain. Since thousands of conventional, mechanical relay switches are necessary, programmers are large and cumbersome; and any change in the logic of the missile system means that checkout equipment must be redesigned to conform.

Many of these problems are solved by Honeywell's Random Access Programmer, a distinct advance in the state of the art. It applies solid state techniques whereby tiny magnetic switches replace mechanical switches, making possible remarkable reductions in bulk and greatly increased signal speed, longevity and reliability.

MISSILE TEST ON TAPE

Pre-punched tape fed into compact random access programmer can monitor a missile continously through all phases of checkout and countdown procedures.

Random Access
Programmer Check
Out Equipment

automatic missile checkout

Solid state switching, random access and punched tape make the Honeywell programmer a fully automatic device that can be designed to monitor any missile throughout all phases of checkout and countdown procedures. The console contains comparator equipment that measures temperature, pressure, frequency, voltage, current, speed, time, weight, resolution and drift.

What's more, the Honeywell programmer is the only system which, when a malfunction occurs, sends a coded message to the operator pinpointing its location.

Advantages

Size. A conventional, mechanical switch with 1,024 switch points occupies 48 cubic feet. The same number of switch points in Honeywell's solid-state switch makes a package only *one-quarter* of one cubic foot.

Speed. Response steps up from milliseconds to microseconds. The new Honeywell Random Access Programmer is capable of a command rate of from 12 to 300 commands per second.

Long life. No moving parts, nothing to break, nothing to wear out. Mechanical and nuisance failures are virtually eliminated.

Flexibility. Because punched tape is the language of the system, even major modifications in the missile require merely a change of tape. No design changes in the checkout equipment are needed.

Malfunction Indication. During checkout and countdown the Honeywell device monitors the missile automatically through signals fed into it in a predetermined sequence. If a malfunction occurs, the device searches, finds and localizes it, then notifies the operator remotely by means of a coded signal. Meanwhile, the missile has been made safe. Repairs may be made quickly.

The new Compact Random-Access Programmer is essentially a data handling system. As such, it's a logical result of Honeywell's 15 years of experience in the accumulation, processing and presentation of data in practically every type of industry. The new device simply represents a wealth of competence turned to military application by the Missile Equipment Division of Honeywell's Military Products Group. It's logical, too, that the new equipment should have many points of technological superiority. For Honeywell development and production capability is devoted to producing a majority of the same missile systems and components that the programmer must check. Corporate-wide support is readily available from other divisions as needed—Datamatic, Seattle Development Laboratories, Aeronautical, Ordnance and Boston divisions, and others.

Since the corporation's business is *measurement* and *control*, the results of much research, development and production across a wide range of closely-related effort is incorporated in the work of Honeywell's Missile Equipment Division.

For a demonstration of solid state checkout—programming system, write Honeywell, Missile Equipment Division, Pottstown, Pa.

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The Chance Vought Crusader's pneumatic systems are ground checked with a glance at the RMC-Lindsay High Pressure Gauges installed in the outside skin of the plane.

3,000 supersonic miles—and a transcontinental record later, they will still be registering accurately . . . as they will for the life of the plane.

Two of the gauges are of the suppressed zero type, registering from 1,000 to 4,000 p.s.i. The other registers from 0 to 4,000 p.s.i.

These gauges have undergone a 50G shock test with no ill effects. They will withstand vibration from 10 cps. to 2,000 cps. at 25Gs, at ambient temperatures from −65°F to +350°F. They are moisture sealed at the crystal.

There is no linkage, no gear train to disintegrate or to cause pointer vibration. The indicating pointer is attached directly to the end of the helical bourdon tube.

MODEL #6903 (Actual Size)

RMC-Lindsay High Pressure Gauges have proved themselves—in performance—on record-setting transcontinental jet flights, on innumerable take-offs and landings, on missile guidance systems, and on missile test stand countdowns.

Whatever your high pressure gauge problems may be, why not let RMC engineering skill provide the answers. Write, wire or phone either of the addresses below.

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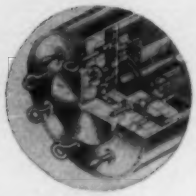
221 Rockwood Street, Rochester 10, N. Y.

RMC
LINDSAY PRESSURE GAUGES

the SUBMINIATURE AND PRECISE RATE GYRO



. . . three to four ounces in weight, this rugged unit has 0.5% linearity to half range, 2% to full range.

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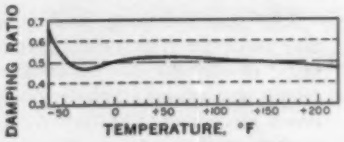

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. . . units on test exceed 10,000 hours at 150°F ambient, 7,000 hours at 200°F ambient.

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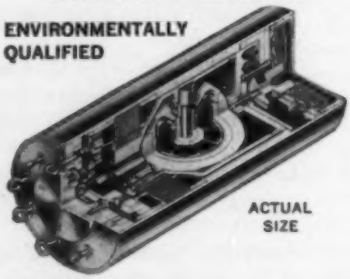

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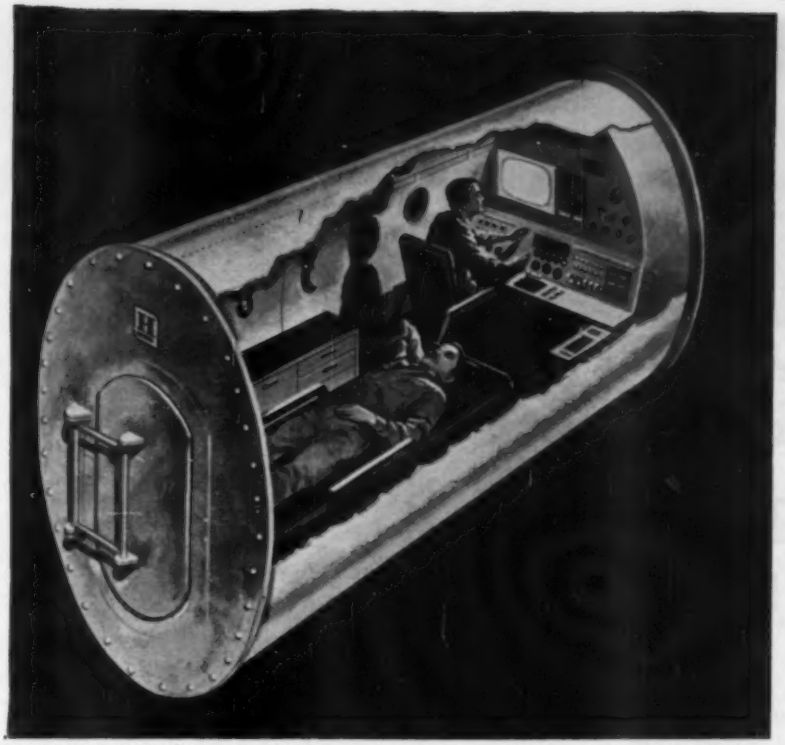


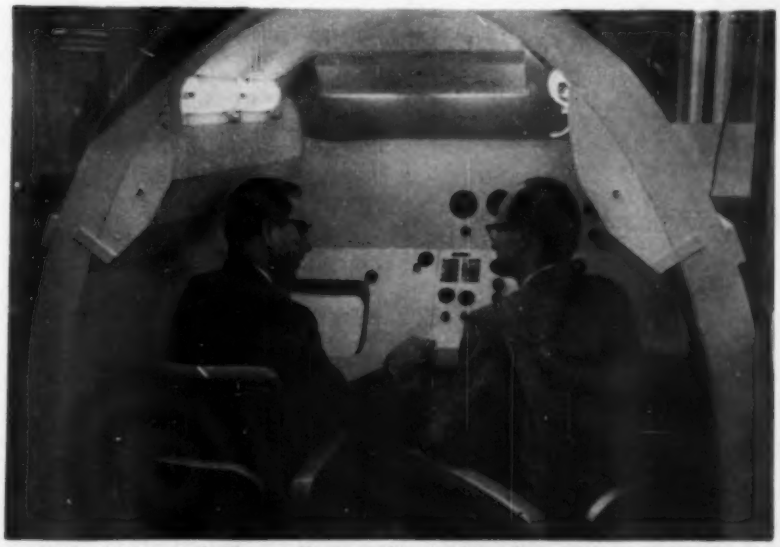
SPACE CABIN simulator will subject two persons to space flight environment for 30 days.

Space Cabin Simulator Being Built

Space cabin simulator designed primarily to study the psychological and physiological stresses on man during prolonged periods of isolation is being developed and constructed by Minneapolis-Honeywell for the Air Force School of Aviation Medicine's Department of Astroecology. Delivery to USAF is scheduled for early fall.

The simulator, an elliptical steel tank 8 ft. high and 12 ft. long, is designed for occupancy by two men over a 30-day period. Complete physical isolation is the major goal.

Observation ports on the side of the simulator contain one-way glass which is opaque from the inside. Closed circuit television cameras used to keep the



MOCKUP of Minneapolis-Honeywell space cabin simulator shows instrument panel layout.

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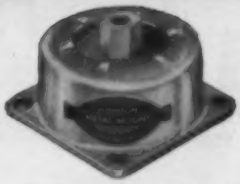

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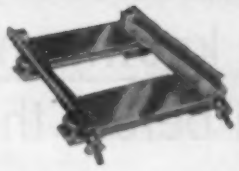

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occupants under constant observation during the test period are concealed behind the simulator's control panel and can be peered through from inconspicuous openings.

Only means of communication available to the test subjects will be by radio. Atmospheric noise and disturbance will be superimposed on their circuit.

Basically, the simulator contains an instrument panel to record and control environmental conditions within the capsule, simulated navigational controls to aid in devising a work cycle and in testing response, a bed, sanitary facilities, food storage areas and cooking facilities.

The atmosphere control system, designed and built by Minneapolis-Honeywell, permits either the occupants or researchers on the outside to monitor and control the pressurization, oxygen, carbon dioxide level, temperature and humidity, but final control is in the hands of the outside monitors. Cabin pressurization can be varied from sea level to 28,000 ft. The outside console records occupant reaction as well as environmental conditions for study by the medical researchers.

The system automatically pumps oxygen into the simulator when it is needed, reduces carbon dioxide through the use of chemical absorption beds, catalytically filters carbon monoxide and increases the nitrogen content if required. It also contains a high voltage electrostatic filter to ionize and trap dust and smoke particles.

Heating and cooling elements automatically control humidity, and a humidity control unit can be used to pull moisture from the air and store it with the water supply.

Control Panel

On the navigational control panel, simulated flight conditions and problems will be presented to the test subjects on a television screen. They will then be required to solve the problems or respond to the simulated flight conditions as they are presented.

The door of the capsule is equipped with an airlock to permit biological specimens to be passed out without appreciably changing the pressurization within the simulator and, in line with the attempt to gain complete isolation, bar the need for direct contact between the occupants and researchers on the outside.

Food for the 30-day stay inside the capsule will be non-perishable, eliminating the need for refrigeration, but a heating element will be provided to warm soup and coffee. Each man will be allotted two quarts of water and 3,000 calories of food per day. They will have two cubic feet of space to store their clothes plus another two feet for personal belongings.

The High Cost Of Progress!

Great gains have been made in space technology during the last decade, but we'll have to leave it to the experts and historians to judge whether or not these gains have been commensurate with the dollar cost.

Unrealistic price and procurement policies contributed to unreliability which in turn pyramided costs. This has been recognized and steps are being taken to correct these problems. How long this will take depends on the vision with which the programs have been conceived and the rigor with which they are implemented.

In the mean time, we should think about the following:

1. How can we put quality and price in proper perspective?
2. Shouldn't we design more safety factor into our systems and components?
3. How can we recapture the craftsman's *pride in excellence* and the engineer's *good old-fashioned judgement?*

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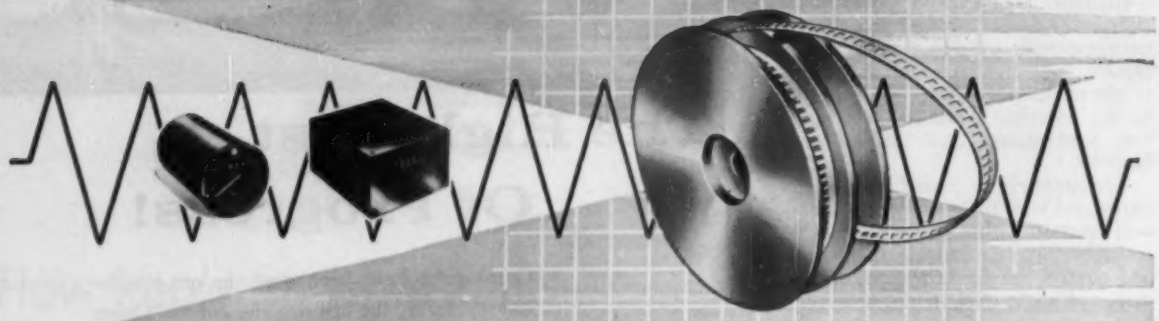

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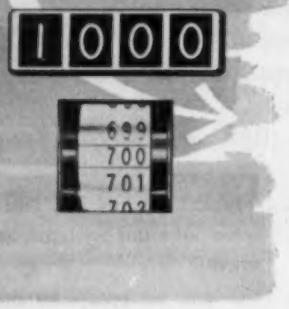

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Available Molybdenum Coatings Resist Thermal Oxidation Effects

Columbus, Ohio—Survey completed by the Defense Metals Information Center at Battelle Memorial Institute here indicates that adequate coatings are now available for protecting molybdenum against high temperature oxidation (AW May 12, 1958, p. 69).

Considerable evaluation and development still has to be—and is being—done in this field. But with few exceptions this work will now be aimed at the improvement of available coatings rather than at the development of new ones.

Existing semicommercial coatings based on chromium, silicon, nickel, the precious metals, ceramic materials and refractory oxides are capable of imparting oxidation resistance to molybdenum and its alloys at temperatures to 2,000F and, in a few instances, to 3,000F and higher.

Most Promising Coatings

No single coating has proven perfect for all jobs, says the Defense Metals Information Center; so in each case the coating must be selected on the basis of its suitability for the intended application.

Among the more promising of the currently available molybdenum coatings are the following:

• **Chromium is highly compatible** with molybdenum, has almost the same coefficient of thermal expansion, and provides moderate oxidation resistance. Brittleness is the major drawback to chromium coatings. Electroplating appears to be the best method for applying chromium to molybdenum although it is difficult to get integral coatings on anything but the simplest shapes. A solution to this coating problem that is now receiving a great deal of attention is the use of a covering electrodeposit of nickel. A nickel layer thickness of about 7 mils over 1 mil of chromium provides 350 hr. of oxidation resistance at 2,000F, 100 hr. at 2,200F and 1 hr. at 2,400F. Compared with other molybdenum coatings, this chromium-nickel electro-deposit also offers good ductility, resistance to ballistic impact and erosion resistance. Resistance to thermal shock, however, is not as great as desired; repeated thermal cycling causes the nickel to separate from the underlying chromium. Interest in chromized coatings applied by pack-deposition has been revived by the development of new materials such as Chromalloy W-2 and Durag MG. Chromalloy W-2 in a 1 to 3 mil thickness will protect molybdenum for 7,200 hr. at 2,000F and 500 hr. at 2,400F.

• **Silicon**, which forms molybdenum disilicide with molybdenum, provides good oxidation resistance at temperatures to about 3,300F, owing primarily to the formation of an impervious layer of silicon dioxide on the surface. With a coefficient of thermal expansion close to that of molybdenum, the silicide coatings also offer high resistance to thermal shock. Carbon can be added to increase refractoriness of the coating for short time service at 4,000F. Molybdenum disilicide coatings are brittle at low temperatures and so are best limited to applications above 2,700F. Coating life is limited by the conversion of surface layers of $MoSi_2$ (molybdenum disilicide) to Mo_5Si_3 which is not oxidation resistant. Small additions of boron suppress the destructive quartz-to-crystobalite transformation that normally occurs at 2,730F and significantly improves the oxidation-resistant life of the coating. The usual method for applying silicide coatings is vapor deposition. A coating 1 to 3 mils thick will protect molybdenum against oxidation for 200 hr. at 2,500F, 100 hr. at 3,000F (1,400 hr. with the addition of 10% boron), and almost 30 hr. at 3,360F. Flame spraying techniques are also being used, particularly on large parts or when vapor-deposition equipment is not available or would prove very expensive. A 5-mil thickness of flame-sprayed silicide provides oxidation resistance for 500 hr. at 2,400F and for a few minutes at 3,600F.

• **Nickel-base coatings** show considerable promise in protecting molybdenum against oxidation particularly in the 1,800-2,000F temperature range. Of prime interest at present are the nickel-chromium-boron and nickel-silicon-boron alloys. Applied by flame-spraying in 5-10 thicknesses, these coatings impart oxidation resistance to molybdenum for 500 hr. at 1,800F and for 500 to 1,000 hr. at 2,000F. They have excellent resistance to impact. Erosion resistance is below that of chromium-nickel electroplates but superior to that of flame-sprayed aluminum-chromium-silicon coatings. Thermal shock resistance is better than that of the chromium-nickel electroplates but poorer than that of the aluminum-chromium-silicon flame-sprayed coatings. Also of

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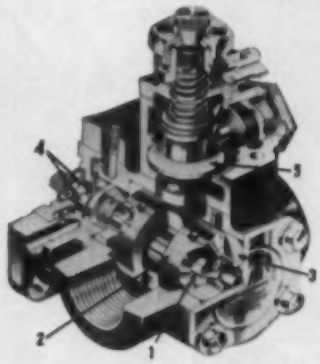

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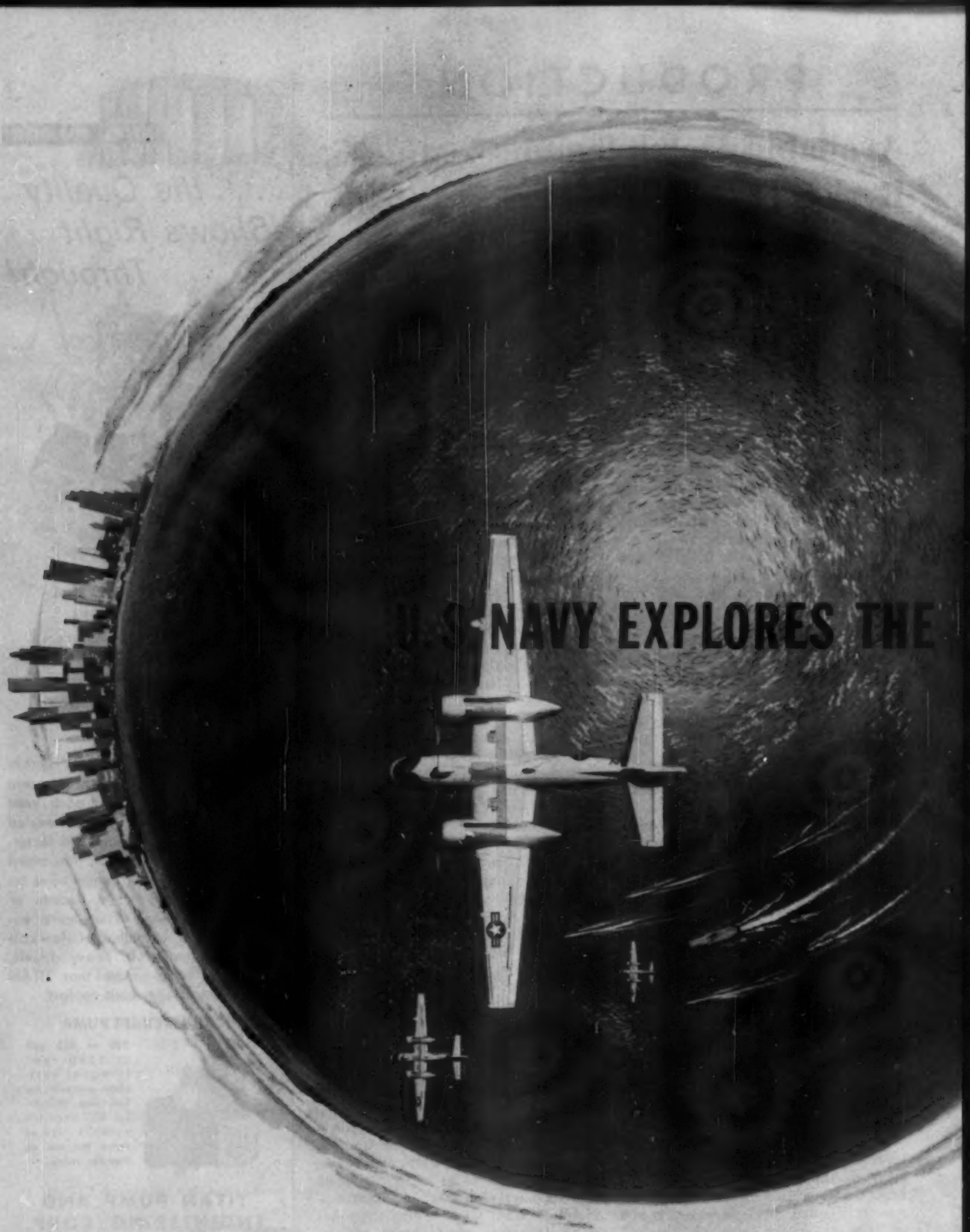

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These nozzles are produced by an arc-spraying process pioneered by General Electric. Tungsten is vaporized in an arc and deposited on a mandrel. For some applications, the liner is molded in lightweight plastic, and the mandrel leached out.

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current interest are the clad nickel-base coatings. A 3 mil thickness of an 80-20 nickel-chromium alloy, according to the Defense Metals Information Center, will protect molybdenum for more than 100 hr. at 1,800F, 100 hr. at 2,000F, and less than 100 hr. at temperatures above 2,000F.

• **Aluminum-chromium-silicon** alloy coatings, applied in thicknesses of 5 to 10 mils by flame spraying, will protect molybdenum for more than 500 hr. at temperatures to 2,000F, for 350 hr. at 2,400F, for at least 6 hr. at 2,600F, and for perhaps 5 hr. at 3,000F. These coatings with a nominal composition of 20Al-40Cr-40Si show good resistance to thermal-cycling failure but fail "drastically" under ballistic impact. Their erosion resistance is approximately half that of the flame-sprayed nickel-base coatings.

• **Zirconium oxide coatings,** applied as a glass-frit suspension and fired to form a glassy enameled finish about 10 mils thick, have reportedly protected molybdenum for as long as 45 min. at temperatures as high as 3,450F. At temperatures below 2,000F, the value of the zirconium oxide-frit is considered marginal as compared with other available coatings. Because enameled coatings are basically glass, their ductility of course falls far short of the metallic coatings. Failures of the zirconium oxide-frits are generally marked by gas evolution, blistering and rupturing of the coating.

• **Chromium-frit coatings,** in the absence of stress, offer continuous oxidation resistance of about 4,000 hr. at 1,800F and 4 to 7 hr. at temperatures from 2,400 to 2,800F. Coating thicknesses generally run from 5 to 10 mils. Unlike their zirconium oxide counterparts, chromium-frit coatings don't blister. Also, they withstand thermal cycling better.

Generally regarded as one of the most promising structural materials for aircraft and missile applications at temperatures above 1,800F (AW Feb. 2, p. 50), molybdenum (and its alloys) has been seriously handicapped by its poor oxidation resistance at these elevated temperatures. Now, however, the development of protective coatings has made it possible for molybdenum components such as turbine buckets to operate for hours in a high oxygen environment at temperatures from 1,800 to 2,000F.

More important, many metallurgists believe that protective coatings will pave the way for molybdenum applications at temperatures significantly higher than 2,500F. Among such applications, some of which are already under development, are rocket nozzles, nose cones, leading edges, afterburners, deflectors and ramjet engines.

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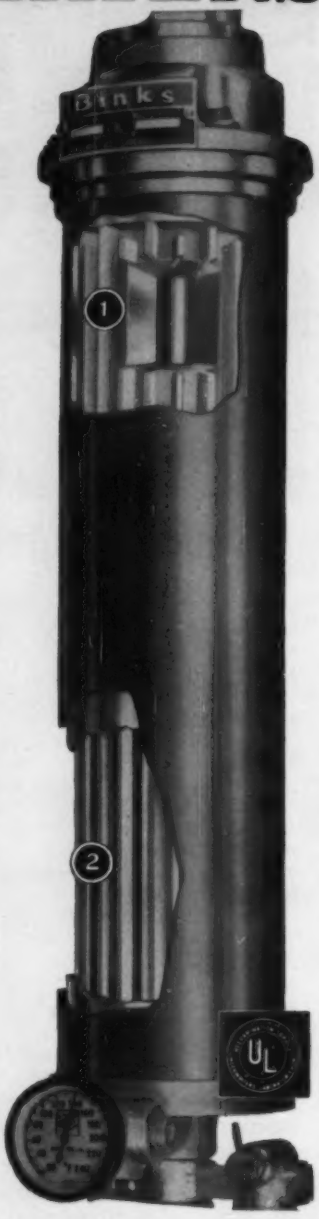

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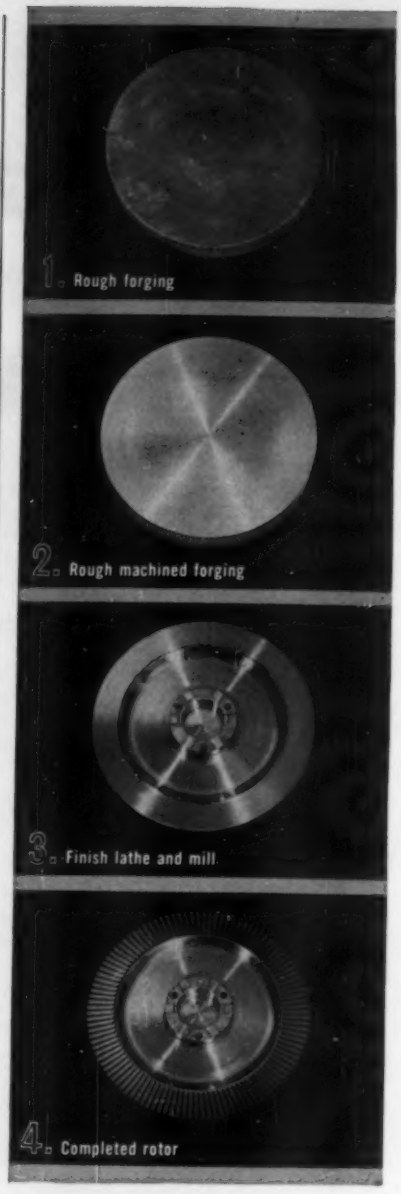

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Report Forecasts Titanium Use Growth

Columbus, Ohio—Future air weapon systems will use more than twice as much titanium in engine and airframe structures as they now do, according to a newly published report by the Battelle Memorial Institute Defense Metals Information Center.

The report, titled "Future Application Trends for Titanium and Steel in Military Aircraft," was made at the request of the Office of the Assistant Secretary of Defense for Research and Engineering. It is based on a survey of more than 80 aircraft companies and government agencies and covers the usage of these two metals anticipated in each individual airframe and engine unit likely to be in production from 1961 through 1968.

In 1961, it is predicted that titanium will account for 2% of the weight of airframes (solid propellant rocket casings and liquid propellant tankage are included here) and 4% of weight of engines. In 1965, it is predicted that both figures will be 8%; and, in 1968, 9%. It is possible, according to the report, that these figures will be considerably higher, perhaps reaching a peak in 1965 of 34% in airframes and 10% in engines.

For steel (just those alloys which can be considered as alternatives to titanium in a given application), the predicted usage figures are 16% of the airframe weight in 1961; 45% of airframe weight in 1965; and 39% of airframe weight in 1968. Percentage of engine weight credited to steel for all three periods is 24. "Possible usage" of steel, the report states, could prove somewhat less.

(As used in the report, "predicted usage" figures are based on titanium usage that is already assured. "Possible usage" figures are those expected if present titanium alloy development and product improvement programs "are reasonably successful".)

Among the more important considerations upon which these estimates are based are the following:

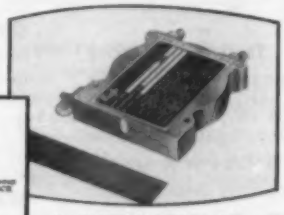
- **Mix of manned** and unmanned air weapon systems will probably persist throughout the period 1961-68.
- **Decided shift** to solid propellant missiles will take place in the early 1960s. As a result, unmanned vehicles will become lighter and simpler. Manned vehicles, meanwhile, will get heavier and more complex due to their quest for greater speed, altitude and range.
- **On a strength/weight** basis, titanium alloys generally will continue to prove the most efficient structural materials available through 1968 for service at temperatures to 1000F (1400F on a

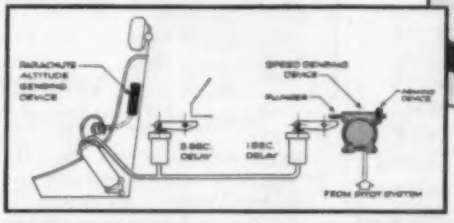
new EMERGENCY ESCAPE DEVICES
solve Automatic Sequencing Problem!

When a pilot ejects at high speeds, seat-man separation is delayed two seconds to prevent injury and parachute tearing. *However, this delay at low altitudes, where ejection is rarely made at extreme speed, may prevent full parachute opening before the pilot hits the ground!*

To reduce this delay and to increase pilot safety at low altitudes, Pacific Scientific has developed a *Speed Sensor* and a *Parachute Release Actuator* for the Air Force that cuts the two second delay to one second – and deploys the parachute in less than 1/10th second! In addition, these two devices permit a three second delay at high speeds – and high altitudes – thus providing the correct sequence of automatic seat separation and parachute deployment under any condition!

Both devices are unusually simple, rugged and dependable. And they are designed to permit easy installation on existing equipment at little cost! This is *the type of reliable engineering ingenuity Pacific can offer your company . . . the capability to resolve perplexing problems with practical, simple solutions.*





Pacific's miniature Speed Sensor (above) and Parachute Altitude Sensing Device (indicated in diagram) are the key elements in this new Emergency Escape System.

If your problem is in controls, instruments, or safety equipment, discuss it with Pacific. Do so today!

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MODEL NO.	MAX. INLET PSI	MAX. OUTLET PSI	FEATURES	MAX. FLOW SCFM
GD10	3,600	500	Single adjustment regulator control	250
GD30	2,500	2,500	Load & bleed valve control	400
GD31	3,600	3,600	Load & bleed valve control	600
GD61C	2,500	2,500	Load & bleed valve control	170
GD62C	3,600	3,600	Load & bleed valve control	200
GD65	6,000	6,000	Load & bleed valve control	250
GD65C	7,000	7,000	Load & bleed valve control	250
GD80A	5,000	5,000	Load & bleed valve control	500
GD81A	10,000	10,000	Load & bleed valve control	800
GD86R	10,000	10,000	For remote control only	1,200
GD100R	6,000	6,000	For remote control only	20,000
GD100	6,000	6,000	Load & bleed valve control	20,000
GD200	6,000	6,000	Load & bleed valve control	50,000
GD700	7,000	7,000	Single adjustment regulator control; self relieving	250
SR10	3,600	1,000	Small, spring loaded regulator	4
LR20B	7,000	7,000	Spring loaded regulator; self relieving	2
LR20BSS	10,000	10,000	Spring loaded; stainless steel	2
LV10	7,000	7,000	Loader valve control	15
BPR10	7,000	7,000	Back pressure regulator	2

Operating temperature range: —67°F. to +250°F.

. . . Yours for the asking Take advantage of Victor's long experience with high pressure gas regulation to help solve your special problems involving flow rates, delivery pressures, corrosive fluids and temperature compensation. Write, wire or phone us today. No obligation.

All models listed are field proved. Most are designed for panel mounting or remote control. They regulate all non-corrosive gases, including oxygen. Stainless steel models available for corrosive gases and pressures above 10,000 psi. For complete specifications, write for Victor High Pressure Regulator sheets.

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short time basis). Owing to the advent of high performance solid propellant rocket engines, tensile criteria will increase in importance. At the same time, higher temperatures will restrict the use of titanium in air-breathing engines designed for speeds of Mach 3 and above. In new engines designed for speeds under Mach 3, titanium will replace more and more of the lower performance, lighter metals.

• **Despite continually increasing** temperature and loading environments throughout the 1961-68 period, airframes in all but one or two of the systems studied will remain cool enough for extensive titanium usage. Significant structural exclusions here are nose cones and leading edges.

• **Vis-a-vis alternative steels,** titanium alloys will continue to be less available and more expensive in the 1960s. In general, fabrication feasibility for titanium and steel alloys will be about the same except for brazing of honeycomb sandwiches and welding which will be more difficult in the case of titanium.

In airframes, the report concludes, there is not the slightest doubt about titanium being an established useful structural material or that it will become even more important in the forseeable future. Original designs are relying more on titanium parts.

In missiles, boosters and space systems, the picture is not yet clear. Eventually, report the authors, W. Stuart Lyman and Fred L. Bagby, titanium is expected to prove at least as useful in long-range missiles and boosters as it will be in aircraft structures. But actual titanium usage in missiles will not be great, they point out, until titanium alloys demonstrate a marked superiority to steel in welded, high performance, solid propellant rocket motor cases and/or there is a significant reduction in the price of "reasonably weldable," high strength, titanium alloy sheet.

Fairchild Modifies F-27 Turboprops

Hagerstown, Md.—Steps to increase takeoff weight of the Fairchild F-27 turboprop transport to 36,500 lb.—up 800 lb.—are being taken here by Fairchild Engine & Airplane Corp.

In addition, landing weight will be raised to 36,000 lb., an increase of 2,000 lb. over original certification. Zero fuel weight of 34,000 lb. will be retained. The program is now being conducted by Fairchild in conjunction with Federal Aviation Agency.

Company said it anticipates that F-27s coming off the production line by the end of 1959 will be certificated for the increased weights. Modification kits will be available.

Reduce Installation Costs of Thermocouple Extensions with THERMO-CABLE

You can now install 6 to 56 pairs of thermocouple leads at one time with "Thermo-Cable," T-E's new multi-conductor extension cable. Installed in conduit, "Thermo-Cable" reduces costs by eliminating the need to pull individual conductors—and permits the use of smaller conduit for the same number of leads. "Thermo-Cable" can also be installed without conduit, in open troughs or in raceways.

"Thermo-Cable's" smooth, polyvinyl chloride outer jacket resists moisture, heat, abrasion and chemical action—and slips easily through conduit. ISA color coded, individual conductors are also insulated in hi-temp (221°F.) polyvinyl chloride—and the conductor bundle is wrapped in aluminum-backed Mylar tape for electrostatic shielding. Pairs are numbered alike and lie next to each other. "Thermo-Cable" is available in 6, 14, 18, 25, 39 or 56 pairs and comes in all standard thermocouple materials.

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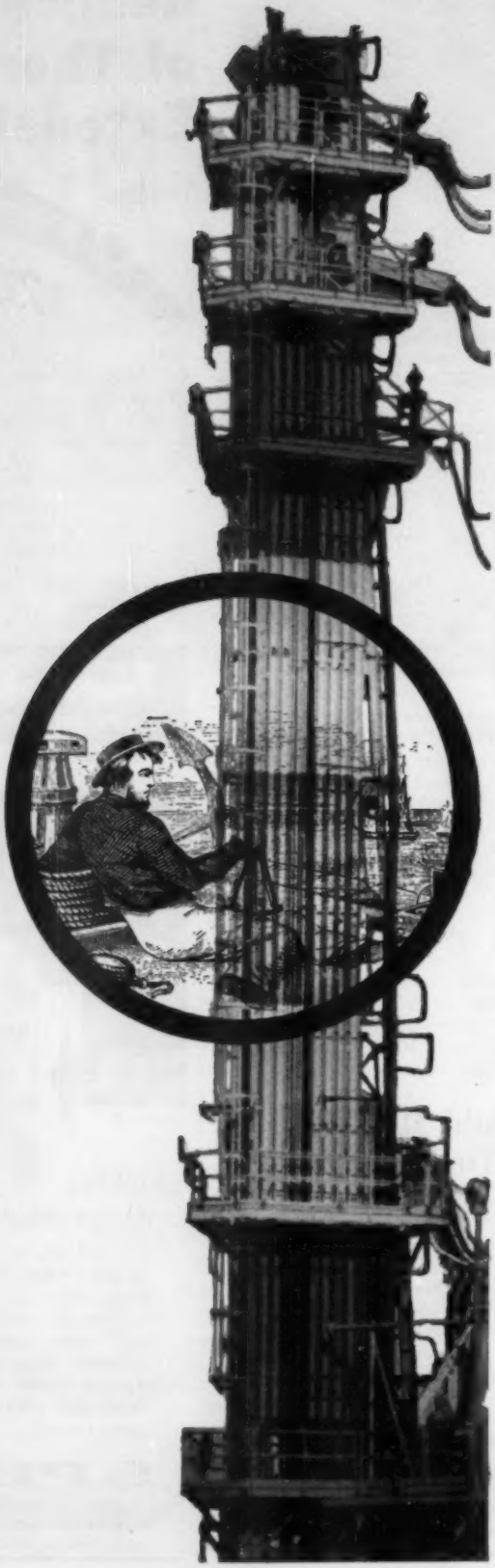

PORT OF EMBARKATION

In the decade of missilery ahead, prime contractor capability must go far beyond the requirements of hardware design and manufacture. New experience and facilities are now required in the increasingly critical launching phase—from ground handling and testing to countdown and data control.

Martin's Cocoa Division is the first organization of its kind devoted exclusively to this specialized area. Accomplishments have already established new operational standards at Cape Canaveral, one of the two U.S. ports of embarkation for the major space events of the decade ahead.

An example of the latest development in electronic fail-safe launching equipment is the new Martin Master Operations Control [MOC] system, which automatically monitors count-down procedures in the test firing of research and development-type TITAN missiles. With equipment such as this, TITAN launchings have achieved unheard-of performance reliability.

Douglas Laboratory Houses Five Tunnels

El Segundo, Calif.—Douglas Aircraft Co. has opened an Aerophysics Laboratory facility here which will be devoted to high-speed aerodynamic testing and will house five wind tunnels with varying capabilities.

Wind tunnels and the status of each is as follows:

- **Completed** and in operation is a 4-ft. square supersonic blowdown tunnel. Speed range is from Mach 1.4 to 5.0, run duration is 40 sec., stagnation pressure is 15 to 350 psia. and temperature is 60 to 200F.
- **Under construction** is a trisonic tunnel, one foot square, that ranges in speed from Mach 0.2 to 3.5. Run duration is 40 sec., stagnation pressure is 20 to 100 psia. and temperature is 60 to 100F.
- **Hypersonic tunnel,** also under construction, has 27 in. diameter, speed range Mach 5 to 10, and run duration from 200 to 300 sec. In this tunnel, stagnation pressure ranges from 600 to 2,200 psia., stagnation temperatures 200 to 2,000F.
- **Hypervelocity impulse** tunnel, to be completed by 1960, will have a speed range from Mach 5 to 20.
- **Light gas gun** ballistic range will permit the firing of models at velocities to 15,000 fps. along a 300 ft. long instrumented range. Tests on rain and sand erosion as well as the effect of different gases on models will be studied.

Aerophysics Laboratory is Douglas-owned and will supplement the company's activities confined until now to cooperative tunnels.

Sabreliner Adopts British De-Icing Unit

First American aircraft to be completely equipped with the British developed Spraymat de-icing system is the North American Sabreliner. The utility jet transport will utilize the electrothermal de-icing system on the wing and leading edge slats, the empennage and the air conditioning inlet ducts.

Spraymat, developed five years ago by D. Napier & Son, Ltd. (AW April 5, 1954, p. 34), has been flying on British and European aircraft for some years. Manufacturing rights to the process in the United States are held by the Pac Aero Engineering Corp., Santa Monica, Calif.

The first application of Spraymat on a U. S. aircraft was on the propeller spinners of the Lockheed Electra. Both Aeroproducts and Hamilton Standard propeller models of the Electra will have Spraymat-coated spinners.

Other aircraft slated to use the

DAY-GLO®
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"SAVED MY LIFE"

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Peter Flagg is president of the C. N. Flagg Company of Meriden, Connecticut... the largest specialized pipe line contractors in the Eastern U.S. The company operates a two-engine, seven-passenger Aero Commander and employs a full-time pilot.

"We were flying along at 8,500 feet," says Mr. Flagg, "when I suddenly noticed a jet turning sharply away not 500 feet from our left wing. He was so close my passengers said they could see the expression on the pilot's face. I am convinced that because my plane was liberally painted with Day-Glo, the jet pilot had time to take evasive action. I feel that Day-Glo saved my life."

This is just one of hundreds of experiences reported on what a gallon or two of Day-Glo Aviation Paint has meant to pilots and control tower operators, too. These provable case histories demonstrate the protection afforded by a paint that is four times more visible than ordinary paint, particularly under poor visibility conditions.

The U.S. Air Force evaluation proved even more dramatic. After a year in which they suffered nine "see-and-be-seen" mid-airs, the Air Training Command decided to paint some 1,600 planes. These aircraft were alive with Day-Glo paint and "see-and-be-seen" mid-airs dropped to ZERO on the fluorescent painted aircraft.

Genuine Day-Glo Aviation Paint with the Filteray® clear overcoat lasts and lasts, according to Flagg. "Even though my plane has been hangared very little since it was painted last summer, the paint job still looks like new."

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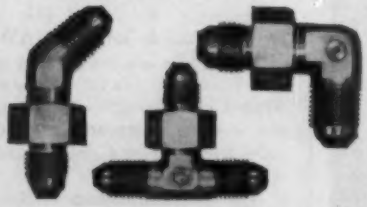

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For further information . . . write in confidence to Batavia or: Dunbar Kapple, Inc., 2205 Grand Avenue, Kansas City; 10835 Santa Monica Blvd., Suite 208, Los Angeles; C. F. Russell Company, Inc., 146 Fourth Avenue, Bay Shore, New York; P. O. Box 28, Altamonte Springs, Florida. Your inquiry will receive prompt attention.

AIRCRAFT COMPONENTS DIVISION

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flame-sprayed electric de-icing system are the Grumman AO-1 observation plane, the Allison-powered Convair 340, the Lockheed F-104 for West Germany which will use the system on the engine inlet ducts. Aircraft for which the system is being evaluated include the Douglas C-133, the Lockheed C-130, the Lockheed JetStar, Martin P6M and the Republic F-105B.

Spraymat consists of a flame-sprayed metallic resistance element—kumanal, an alloy of manganese, copper and aluminum—embedded in an epoxy resin coating. Additional epoxy layers provide insulation and protection from rain and stone erosion.

De Havilland Plans Design Team Center

London—De Havilland Aircraft Co., Ltd., is planning to centralize its design team at Hatfield. The move will strengthen its design and technical department to meet growing competition in world markets, the company said.

Designers presently are divided between company headquarters at Hatfield (Hertfordshire) and a manufacturing plant at Christchurch (Bournemouth) where the de Havilland Sea Vixen aircraft is produced.

In September, about half of the 200-member technical team at Christchurch will transfer to Hatfield, according to de Havilland. The remainder will stay on liaison with the manufacturing side while the Sea Vixen is modified.

PRODUCTION BRIEFING

Solar Aircraft Co. has unveiled a new 950-lb. gas turbine engine that produces 1,250 eshp. Engine, designated Saturn, has specific fuel consumption of 0.60 lb./per/hr. and is built in both constant and variable speed versions. Engine has application for generator sets, boat propulsion units and compressor and pump drives. First customer is U. S. Maritime Administration which will use it as cargo ship generator.

General Electric has received a $5 million contract for production of J79 turbojet engines which will power Lockheed F-104 Starfighters sold to Federal Republic of Germany. Letter contract is partial funding for a larger over-all contract. Another J79 contract, for $4 million, has been placed with GE by Air Materiel Command's Aeronautical Systems Center, for use in U.S. Navy aircraft.

Dassault 415 Communaute will be fitted with Turbomeca Bastan turboprop engines before further flight test-

New, from Task Corporation... the only complete line of Refrigeration systems and components designed specifically for flight and air transportable applications operating from 400 cycle/200 volt power.

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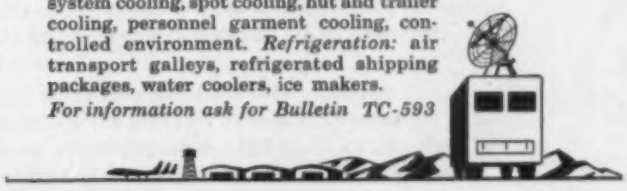

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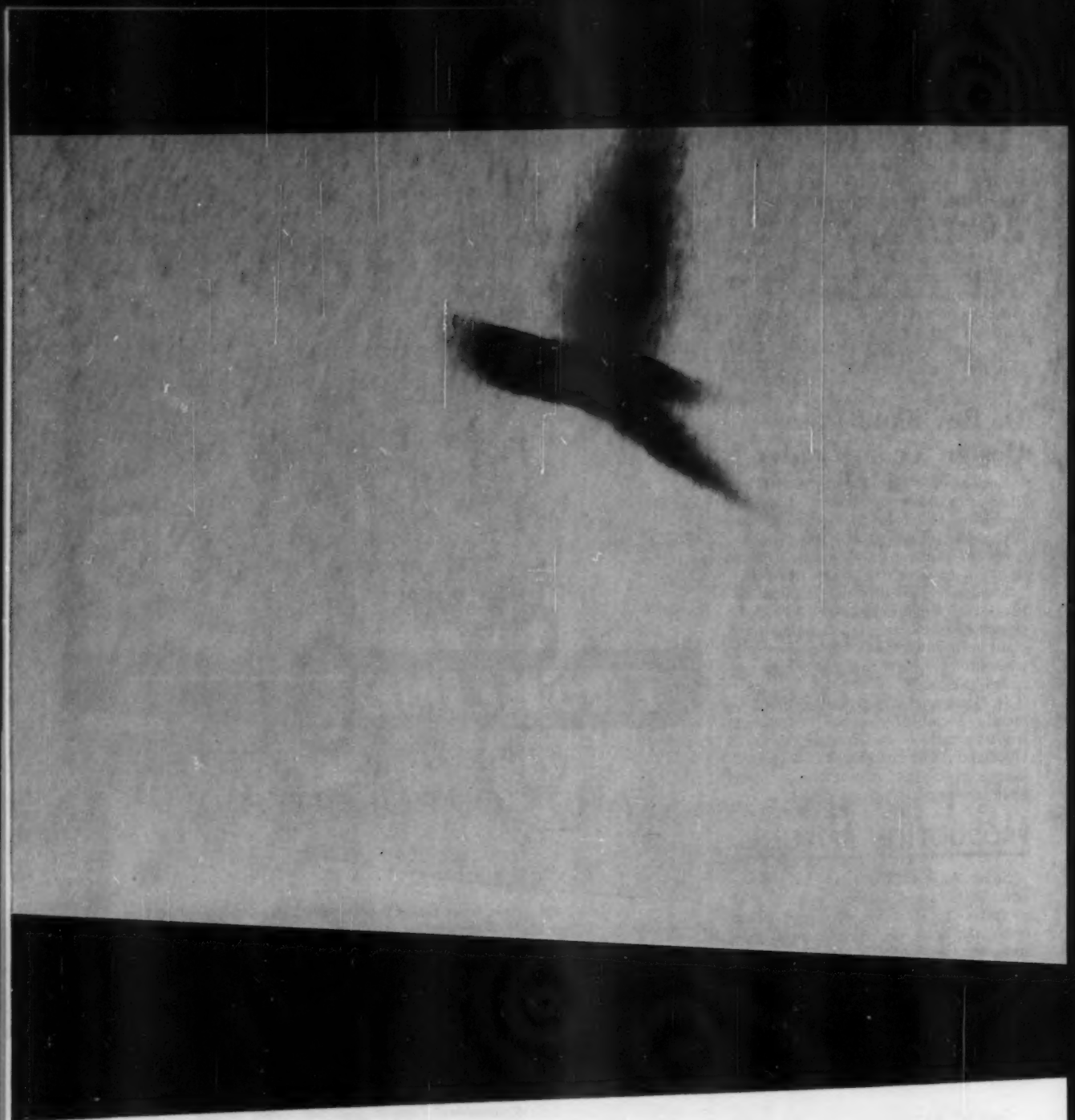

The Shape of Flight The shapes of things that fly have always been determined by the materials they are made of. Feathers form wings that are basically alike for all birds—and membrane forms an entirely different wing for insects. It takes thousands of years, but nature improves its materials and shapes, just as technology improves the materials and shapes of aircraft. But here the improvements in materials are so rapid that designs become obsolete almost as soon as they are functional.

Today, the aeronautical designer has types of materials that didn't exist just a few short years ago. Steel is a good example—*five* new types have become available in the past year through USS research: USS Airsteel X-200, an air-hardenable alloy steel with 230,000 psi yield strength; USS Strux, an alloy steel with close to 300,000 psi tensile strength; USS 12 MoV and USS 17-5 MnV Stainless Steels for high speed aircraft and missiles; and USS Stainless "W", a precipitation hardenable stainless steel.

Write for complete technical information about these remarkable new materials.
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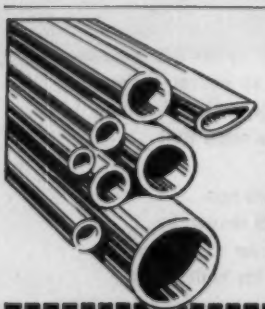

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ing. Aircraft made its first flight May 10 and has flown almost 6 hr. since in tests for stalls, low speed and flap and speed brake operations.

Northrop Corp.'s Norair and Nortronics Divisions will reduce work forces by 1,450 employes by Aug. 1. Company said the reduction is to reduce overhead plus a downward adjustment in personnel to meet current requirements.

Flight testing of General Electric's CJ805-3 turbojet engines has passed the 2,000 hr. mark, using Douglas XF4D and Douglas RB-66A (AW April 13, p. 149) as testbeds. The engines will power the Convair 880 jet transport.

Airaterra, Glendale, Calif., fluid system component producer, registered sales of $650,000 in April, the highest in the company's history.

Hercules Motors Corp., Canton, Ohio will supply gasoline engines for 159 USAF runway snowplows under an $800,000 contract. Snowplows, both rollover and straight type, will be built by the Oshkosh Motor Truck Co., Oshkosh, Wis.

Vitro Laboratories, Silver Springs, Md., moved into a 100,000 sq. ft. annex which increases its plant capacity by 30%. The $400,000 addition will be used for weapon system study under Navy contract.

United Enterprises, Inc., New Orleans, La. will build a $510,000 hangar at Cape Canaveral, Fla., for assembly of the Martin Mace missile. Building will be used to check out and assemble the missile for flight tests.

Hydromatics, Inc., Livingston, N. J., maker of missile ball valves, has established a West Coast Division. The new division, located at 7120 Remmet Ave., Canoga Park, Calif., will have complete engineering and manufacturing facilities.

Waste King Corp.'s Technical Products Division, Los Angeles, Calif., will supply Northrop Corp. with 30 two-speed accessory drives as a follow-on to an original order of 25 for use on the Northrop T-38 jet trainer. Gear boxes drive a 400 cycle 8-kva. alternator and a hydraulic pump supplying one-half the electrical power and one-half the hydraulic power for the aircraft.

Sundstrand Corp. is the new name of the Sundstrand Machine Tool Co., Rockford, Ill. The company's Aviation Division will be known as Sundstrand Aviation. The name change reflects corporate diversification.

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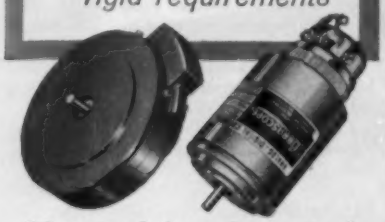
Shaft-to-digital encoders meet rigid requirements



Librascope shaft encoders meet and surpass rigid requirements of airborne analog-to-digital translation. Shock, vibration and temperature extremes do not affect their continuous, noise-free operation.

THEY'RE DIRECT: A simple one-step means of digitizing analog data.

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THEY'RE VERSATILE: 14 basic models in wide range of capacities; special function codes built-in to simplify computer requirements.

For full details on Librascope encoders write for Catalog E11-1

OUTPUT CODE	MODEL NO. ◎	TOTAL CAPACITY	RESOLUTION PER TURN
PARALLEL BINARY (LINEAR)	740	10 bits (1024)	1024
	743	13 bits (8192)	128
SERIAL BINARY (LINEAR)	707	7 bits (128)	128
	713	13 bits (8192)	128
	717	17 bits (131,072)	128
	719	19 bits (524,288)	128
SERIAL BINARY (SIN-COS)	757†	7 bits per quadrant* (4 quadrants)	512
	758†	8 bits per quadrant* (4 quadrants)	1024
BINARY CODED DECIMAL (8-4-2-1)	723	2,000	200
	724	20,000	200
	733	3,600	200
	734	36,000	200
	735	360,000	200
GRAY	709	8 bits (256)	256

◎All models available with internally mounted isolation diodes for sequential multiplexing applications.

†Available in hermetically sealed servo-driven package as Models 757-S and 758-S.

*Including limit 1 and polarity information. Sine and cosine functions generated simultaneously and independently. One turn of shaft generates 4 quadrants of information.

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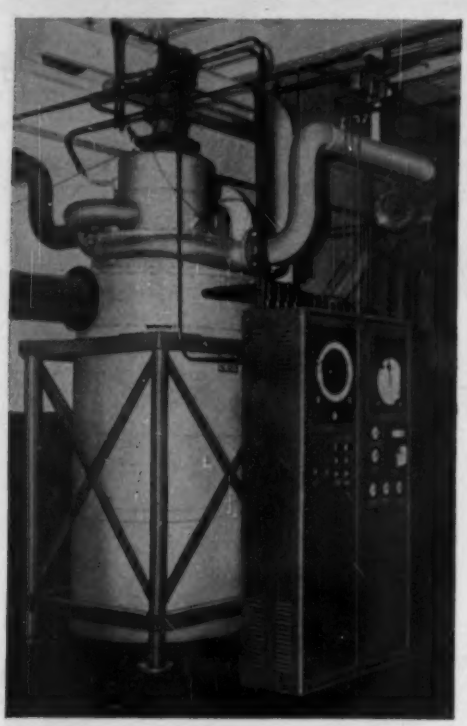

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WHO'S WHERE

(*Continued from page 71*)

Changes

Capt. Sam Peters manager of flight operations, Pan American World Airways' Pacific-Alaska Division. **Capt. Don Kinkel** succeeds Capt. Peters as chief pilot. Also: **Milton Patterson,** cargo sales superintendent for the Division.

Hoffman Laboratories Division of Hoffman Electronics Corp., Los Angeles, Calif., has appointed **Albert D. Emurian** East Coast manager of Hoffman's phase of the Air Force's global communications complex, Air Com (Project 480L).

Howard R. Hammond, general manager, newly created Defense Products Division of Allis-Chalmers Mfg. Co., Milwaukee, Wis.

John R. White, manager of the new Monitor and Control Division, Fenwal, Inc., Ashland, Mass.

Lawrence Saper, director of engineering, Eastern Division of Acoustica Associates, Inc., Plainview, N. Y.

Edwin N. Lent, director of manufacturing, Texas Division of Collins Radio Co., Dallas, Tex.

Victor E. Caffee, assistant director of materiel, Aerojet-General Corp., Azusa.

Rodney D. Chipp, director of engineering, ITT Communication Systems, Inc., Paramus, N. J., a unit of International Telephone and Telegraph Corp.

Alexander B. Magnus, Jr., staff analytical engineer and design specialist, Actuation Research Corp., Glendale, Calif.

John B. Boddie, manager of schedules, American Airlines, Inc.

Wilbur W. Maves, director of testing, Astrolab Testing Corp., El Monte, Calif.

Robert L. Jackson, production manager, Scientific and Process Instruments Division of Beckman Instruments, Inc., Fullerton, Calif. **John V. Spray** succeeds Mr. Jackson as manager of quality control.

Thomas G. Kamp, general manager, Control Data Corp.'s Cedar Engineering Division, Minneapolis, Minn.

Gerald J. Tobias, assistant to the director, Military Equipment Division of Fruehauf Trailer Co., Detroit, Mich.

Arthur Link has joined the Garrett Corp., Los Angeles, Calif.; as a member of the corporate research and policy groups, he is a consultant on missile and electronics projects.

George H. Ward, manager-applications-J85 Project, General Electric's Small Aircraft Engine Department, Lynn, Mass., succeeding **Newell N. Davis,** now on special assignment-marketing studies.

Norman J. Golden, manager-transistor section, Semiconductor Division, Hoffman Electronics Corp., Los Angeles, Calif.

Dr. Arthur M. Ross and **George L. Sansbury** have joined the engineering laboratory of Hughes Aircraft Co., Tucson, Ariz., as senior members of the technical staff.

W. J. Wallace, Jr., assistant to the president and director of public relations, Intercontinental Electronics Corp., Mineola, N. Y.

Walter K. Dan, Jr., sales manager Kearfott Co., Inc., Microwave Division, Van Nuys, Calif.

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Cable Core	Modified semi-solid silica.
Outer Conductor	Single braid, AWG size 32 coated oxygen-free, high-conductivity copper wire.
Jacket	Flexible special metal alloy. Nominal overall diameter: .525".

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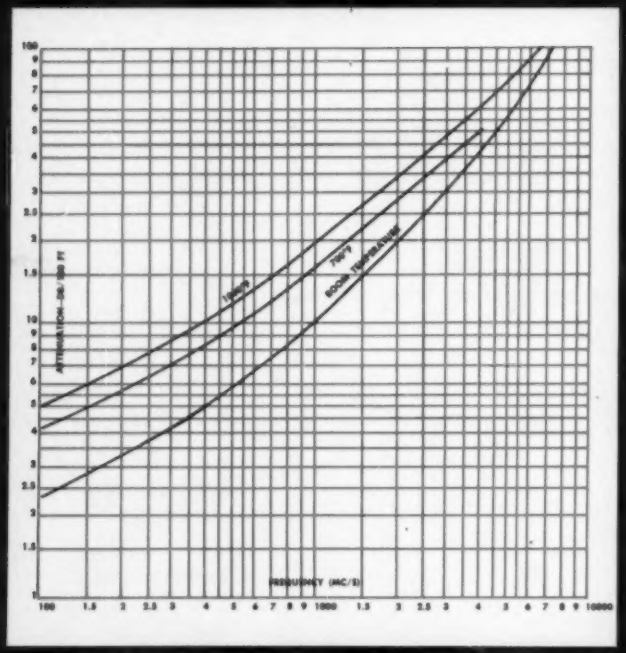
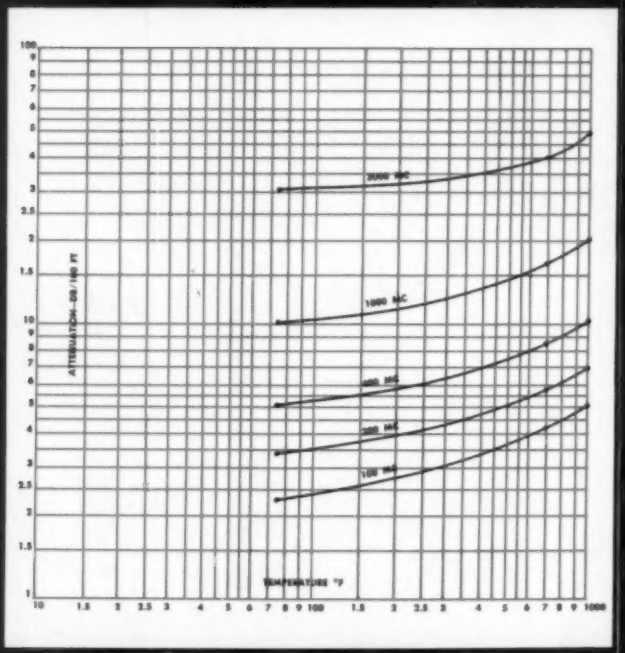


ATTENUATION VS. FREQUENCY AT ROOM TEMPERATURE, 700°F and 1000°F



ATTENUATION VS. TEMPERATURE AT VARIOUS FREQUENCIES

(See Other Side)

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Atwood Backs Weapon Systems Concept

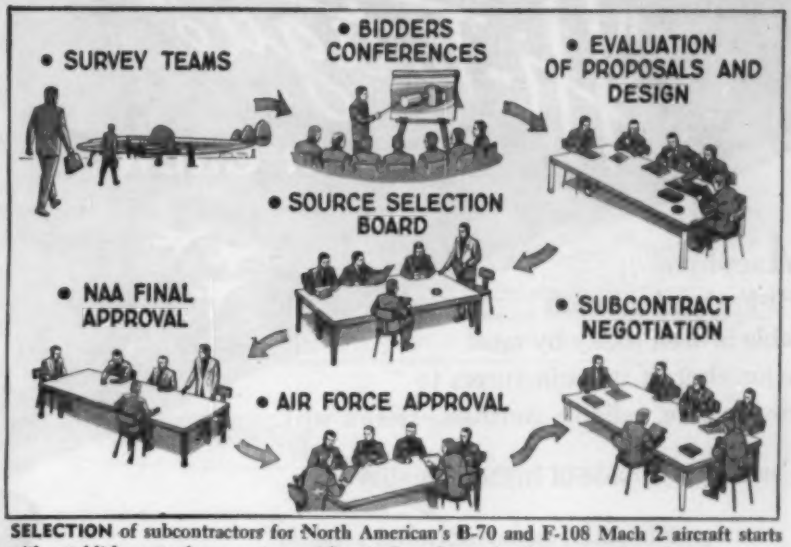
By Irving Stone

Los Angeles—The weapon system concept will endure and its execution will continue to improve even more as progressive experience is gained, according to J. L. Atwood, president of North American Aviation, Inc.

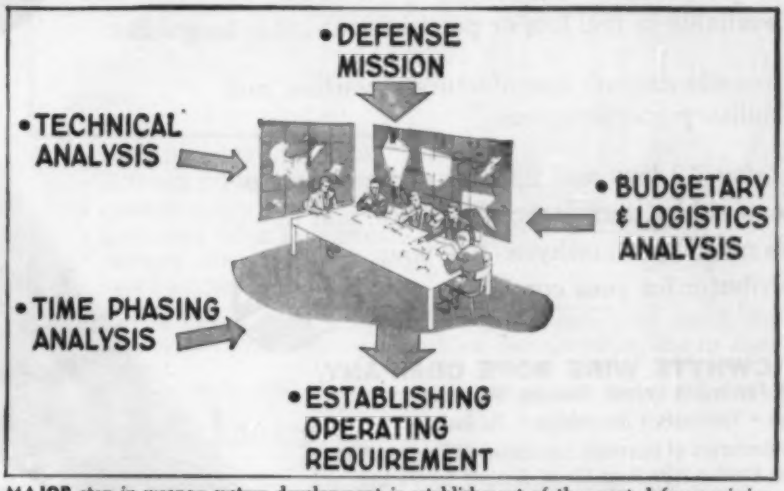
North American is prime contractor for the most advanced and complex manned weapon systems ever scheduled for the Air Force inventory—WS-110A (B-70 intercontinental Mach 3 bomber) and WS-202A (F-108 long-range Mach 3 interceptor).

Speaking generally, weapon system development will be accomplished faster and more economically, as time goes on, through ordinary improvement in management techniques and other skills, Atwood told AVIATION WEEK.

Atwood is concerned about superficial opinions that there is some way to achieve something simple and final to solve the nation's defense problem. Everyone likes simplicity, he points out, but defenses and deterrents are difficult and permanent problems. Scientific solutions must be sought for the difficulties involved and this scientific knowledge continually applied, so that at the appropriate time it may be available for advanced weapons.



SELECTION of subcontractors for North American's B-70 and F-108 Mach 2 aircraft starts with establishment of survey teams (above); flow shows developments after that.



MAJOR step in weapon system development is establishment of the exact defense mission, with secondary steps, such as technical analysis and budgetary analysis following.

Strategic Field

Atwood doesn't believe that missiles will eliminate aircraft, or that any other single approach is the final end to the country's efforts. He emphasizes that there must be in being and in development, in the strategic field, the best missile that can be devised and the best manned intercontinental system which can be developed. And, in the air defense field, the best missile and the best interceptor which can be devised.

The country must be able to afford these systems, he emphasizes. If the country can't achieve these four categories, and whatever tactical weapon systems may be required, a big hole in our capability will exist, he declares. Paralleling this development are all the networks and warning aids, ground strength and logistics, which also are essential areas.

When a weapon system is laid down, it is implied that it will be used on a considerable scale, with terms which seem to exclude an experimental vehicle, in that it is necessary to know how the system will be built and what its capabilities will be. Thus North American is not dependent on any new inventions in turning out the B-70 weapon, which involves the present state of the art, or moving out a bit beyond to a point which North American engineers feel they can reach without introduction of major uncertainties. In this way, the development can be scheduled and budgeted confidently, Atwood maintains.

This is in contrast to the development of the long-range ballistic missile, he points out, which went along at a relatively low rate for a number of years. State of the art here wasn't comparable to that relevant to the case of the B-70 but, rather, many unknown frontiers remained to be pierced before reaching design and production status. Problems for the ICBM theoretically were bracketed in 1954, and large scientific groups were mobilized to resolve problems in the fields of astronomy, upper air physics, and many other areas before a status of practicality was achieved. At the same time, some weapon development was pushed.

This was a much broader attack than that involved in the B-70 intercontinental bomber. Atwood feels that a

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weapon system should not ordinarily be approached in this manner.

Atwood contends that the scientific parameters must be kept in view and the fund of knowledge generated, through research, on the elements in the various problem areas. This type of research—vitally important, he says—is conducted in universities, government laboratories, and at contractor facilities.

Acquisition of this basic scientific pool of knowledge, actually an elemental stage, though not necessarily a part of weapon system development, is the base or framework on which the weapon system is erected. When enough scientific progress has been made in the various areas involved, the weapon system reasonably can be scheduled. This is the normal approach, Atwood emphasizes, in contrast to that which was involved in the development of ballistic missiles, an unusual approach which combined both basic research and development.

For each new weapon system a new level of accomplishment in the field of basic research is required. But the weapon system development, Atwood emphasizes, should not be required to carry along the basic scientific work needed to attain the higher level of technical knowledge involved. Weapon system objectives, in turn, point the way to better scientific objectives, he declares.

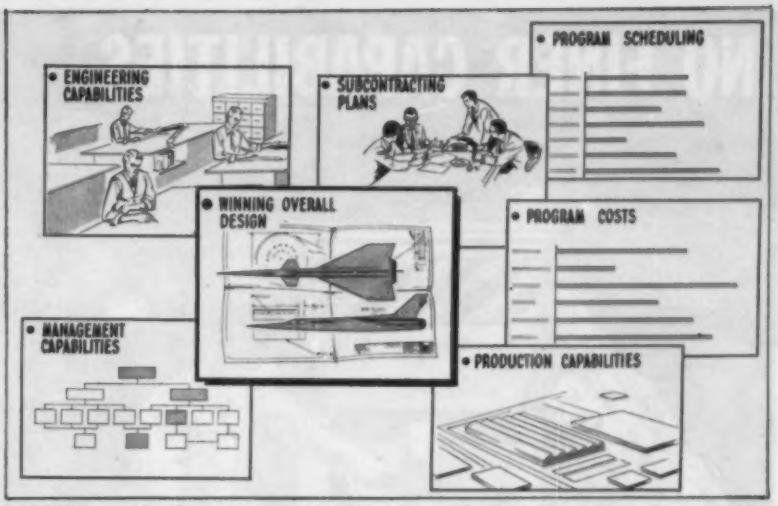
Competitive Approach

Atwood feels strongly about the competitive approach for weapon system design and development. This work is better adapted to our structure of industry than any single "design bureau" concept, Atwood declares, although this type of establishment has great value in originating many good ideas, and does have a definite function.

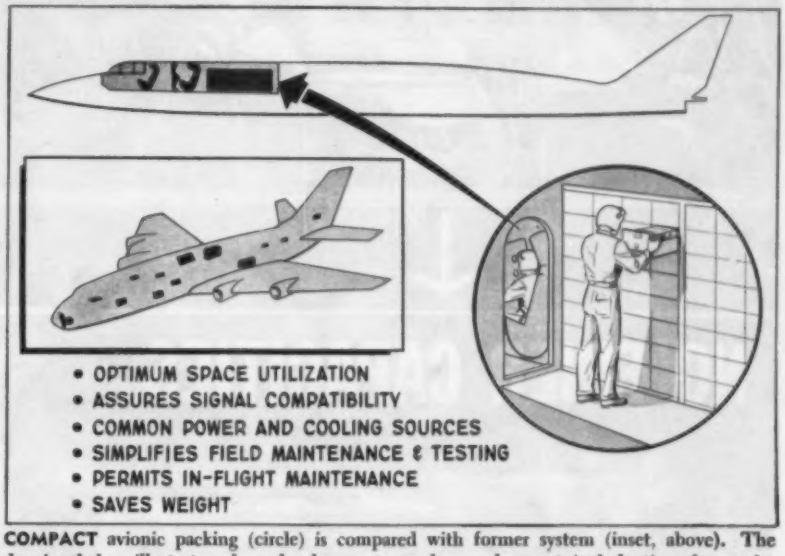
Weapon systems today involve considerably more training of military personnel. The contractor is more intimately associated with the training phase than in the past because of the nature of the weapon system and its integration by a single weapon system manager. Training becomes a more complete effort, more logically presented to operational people by the weapon system manager to develop their background skills.

A broad picture of the weapon system concept and how it is implemented specifically by a prime contractor, such as North American Aviation, was delineated recently by Atwood before the House of Representatives' Armed Services Investigating Subcommittee (AW April 20, p. 31).

"Weapon system" may refer to any unit of military power, such as an airplane or missile, together with all its related equipment, supporting facilities and skills required to maintain and op-



FACTORS considered in weapon system contractor evaluation (above) range from engineering capabilities to the size of the plant necessary to complete the job.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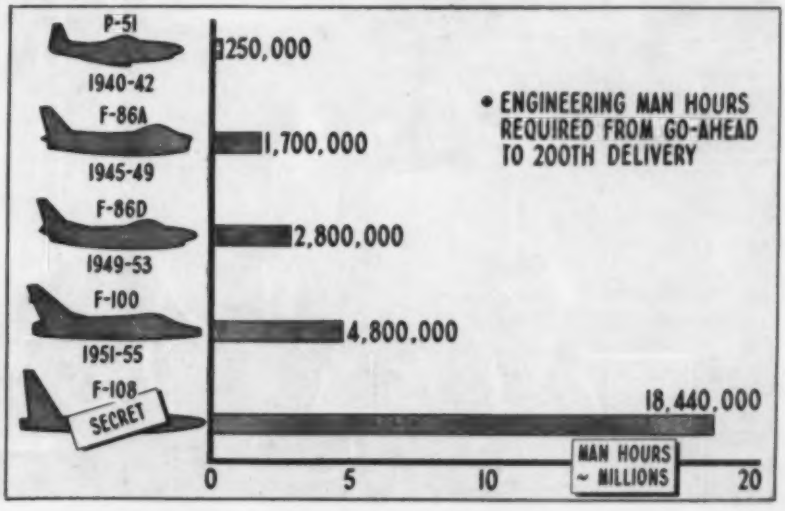
COMPACT avionic packing (circle) is compared with former system (inset, above). The drawing below illustrates plane development man-hours, does not include time for equipment development.



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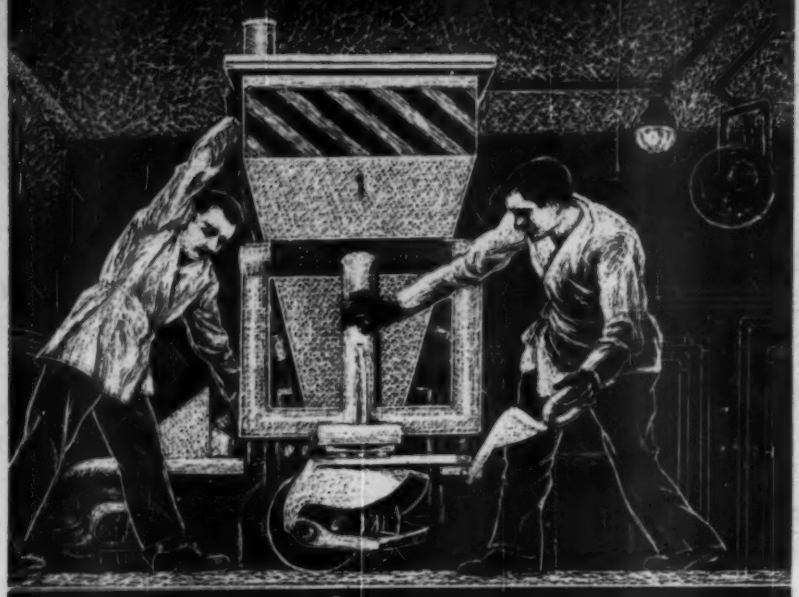
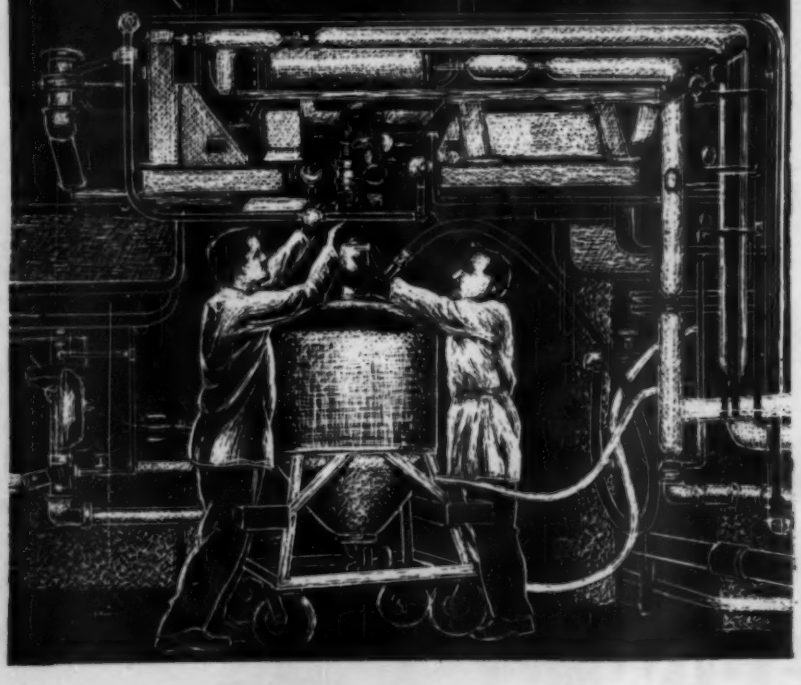


NO FINER CAPACITIES



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crate it in combat. Weapon system contracting, as we know it today, Atwood pointed out, has been evolved to make possible the development of optimum defense equipment at minimum cost and lead time in a period of rapidly accelerating technological progress.

Using a simple approach to describe the implementation of a weapon system, Atwood emphasized that it is not only the prime contractor who carries a large technical and managerial responsibility under the system development program. Through the system approach to equipment development, business principles of specialization and decentralization are used, bringing together in one large package a number of related items of equipment.

He emphasized that an important share of responsibility is borne by each of the first-tier major system contractors, and a proportionally declining share by each lower tier of subcontractors.

The prime contractor assumes overall responsibility for coordinating the myriad technical decisions, taking inputs from the customer and from each of the major systems companies, evaluating all the factors that may affect optimization in a particular design area, and providing necessary design guidance to the system companies in order to achieve the optimization and balanced performance against schedule and cost considerations. The same process is repeated down the line through the successive tiers of subcontractors so that what might otherwise prove an impossible coordinative and technical management problem is logically distributed, assuming reasonable proportions at each level of the pyramid.

Systems Advantages

Broad advantages seen by Atwood in weapon systems contracting to make it possible to procure today's extremely sophisticated weapons within minimum time and cost limitations, include:

• **Military service** retains control of the weapon system program while giving sufficient latitude to the prime contractor to do the job. At every major step in the design and development phases, the military maintains a decision-making prerogative. A representative of the military service maintains residence surveillance over the program at the contractor's plant. The same kind of milestone reporting and cost-accounting required of the subcontractor is in turn required of the prime contractor, Atwood pointed out. But the prime contractor is given authority to deal directly with subcontractors in such vital areas as integration and test of related subsystems. Problems arising from changes in specifications requiring changes in other components or systems may be handled directly between the contractors.

• **Most advanced** weapon systems possible are provided in any given time period, because design of a weapon system is permitted around a number of subsystems that are not yet fully developed. Under weapon system contracting, integration begins in the design stage. Subcontractors are providing the most advanced projections in the system specialty that they can reliably schedule and their technical and managerial skill in making these projections materialize. Innovations appearing in industry during the developmental period may be fitted into the program more readily under the weapon system plan, because there is effective machinery for fast coordination and integration of changes. In this way there is provided a systematic means for utilizing the most advanced technical developments that are being made in the broad base of industrial and government-sponsored research and development that is constantly being pushed in such lines as engines, radar, navigation, armament, hydraulics, computers and automatic controls, Atwood pointed out. He emphasized that weapon system contracting is not contradictory to a broad base of technical development, but rather depends upon and proceeds from such a base.

• **Responsibility for development** of a weapon system is centered in an organization familiar with production problems. Weapon system contracting, he said, enables production problems to be faced and solved throughout the design and development stages, thus avoiding later compromises which would

Navy Tests McDonnell F4H Armament

Navy's McDonnell F4H two-seat, Mach 2 all-weather fighter is undergoing armament development tests under Pacific Missile Range control off Pt. Mugu, Calif. Three Raytheon Sparrow III air-to-air missiles can be seen in partially-imbedded belly mounts. Aircraft is powered by two General Electric J79 turbojet engines; in tests at Edwards AFB it has approached the world altitude record of 91,249 ft. Wing is swept back at a 45 deg. angle and the horizontal stabilizer has a 23 deg. anhedral.

BEARING BRIEFINGS

One in a series of technical reports by Bower

ROLLER GUIDANCE– VITAL FACTOR IN BEARING LIFE

Roller guidance has been established by the Anti-Friction Bearing Manufacturers Association as a major rating factor for roller bearings. There is a direct relationship between this factor and the life and capacity of a cylindrical roller bearing under load.

Figure 1 illustrates the results of a loose fit between a roller and the guiding ribs of the raceway. Because of lack of guidance by the ribs, the roller is free to skew and skid under load. Such a condition invariably leads to early bearing failure.

To achieve close roller fit and proper roller guidance, Bower precision grinds each bearing race on specially designed centerless grinders. In this operation, Bower positions the integral raceway ribs *from the theoretical centerline of the bearing*. This method produces bearings with high dimensional accuracy and perfect symmetry.

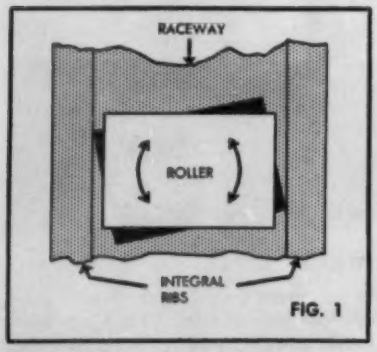
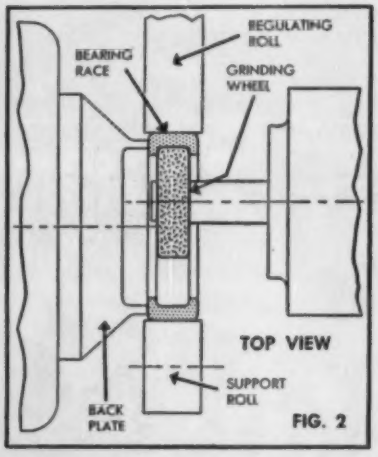
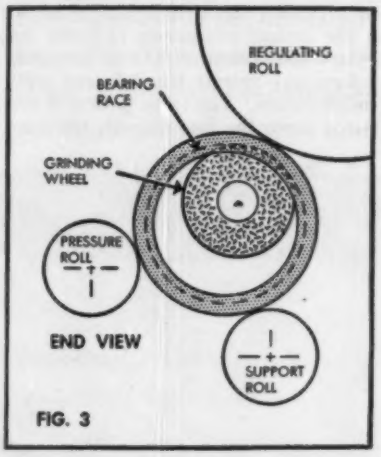


Fig. 1. Loose fit in raceway means poor roller guidance. Roller can skew and skid under load.

In addition, the close tolerances held in grinding the roller track and integral guiding ribs give Bower cylindrical roller bearings the ability to *take thrust in any direction*. A Bower cylindrical roller bearing has thrust capacity of from 10-15% of its rated radial capacity!



Figures 2 and 3 diagram the centerless grinding method used to finish Bower raceways. Use of this technique assures not only optimum roller guidance and maximum bearing life, but also virtually eliminates bearing runout. BEARING SYMMETRY WHICH RESULTS FROM THIS TECHNIQUE PERMITS ACCURATE SHAFT LOCATION REGARDLESS OF HOW THE OUTER RACE AND ROLLER ASSEMBLY ARE INSTALLED. IT COMPLETELY ELIMINATES THE POSSIBILITY OF IMPROPER INSTALLATION.



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downgrade the performance of the weapon.

• **Rapid advance** of the state of the art is making it difficult to use standard subsystems and major components except within weapon systems of the same generation. However, in moving much farther into the area of small components and parts, the weapon system contractor often is able to establish a higher degree of standardization, Atwood said.

• **Closer control of lead time** is possible. Estimating the total effect required and knowing the time limits established by the military service, the weapon system contractor is able to plan the development cycle so that each subcontractor is using sufficient manpower and facilities to get the job done on time. Also, a schedule of reports keeps the prime contractor alerted to possible delays and bottlenecks so they may be dealt with before they become emergencies.

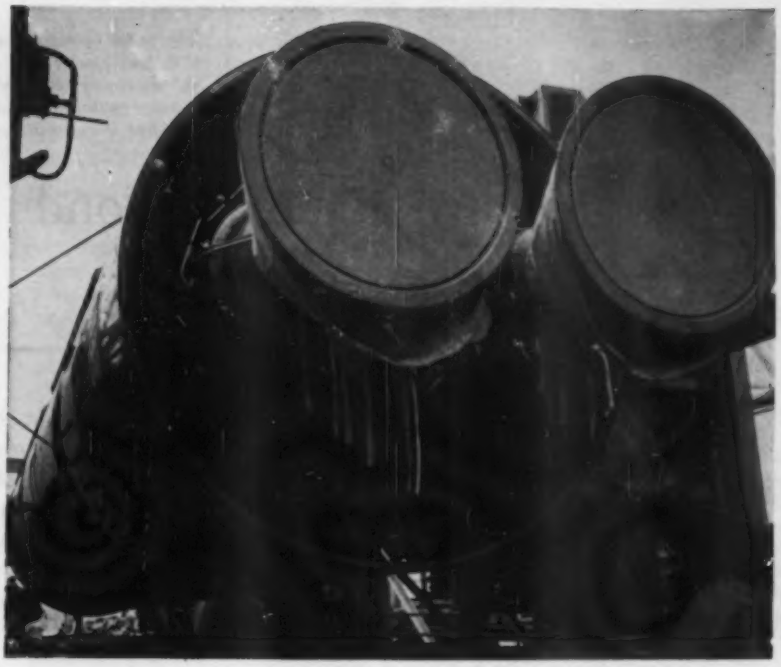
• **Closer control of costs** is possible. For the first time a single organization, the prime contractor, is cognizant of the entire cost of a weapon system program, Atwood emphasized. Also, in negotiating with a subcontractor on the estimated costs for a subsystem, the weapon system contractor will tend to be extremely realistic because of budgetary restrictions and the limited availability of funds, he said. In evaluating the subcontractor's cost reports during the development period, the weapon system contractor is able to apply its own operating experience. It knows what the subcontractor should be doing, and knows what steps must be taken to correct possible cost overruns, Atwood declared.

Cost Aspects

Elaborating on the aspect of costs relating to the B-70 and F-108, Atwood said Phase I and Phase II contracts covering the development of these weapon systems were necessarily of the cost-reimbursement type, because no basis exists for fixed-price bidding or negotiations. One of the contract tasks, he pointed out, is the preparation of specifications, which would be necessary in advance for the quotation of fixed prices. In the case of the B-70 and F-108 programs, North American is proposing a fee representing 6½% of estimated costs, he revealed.

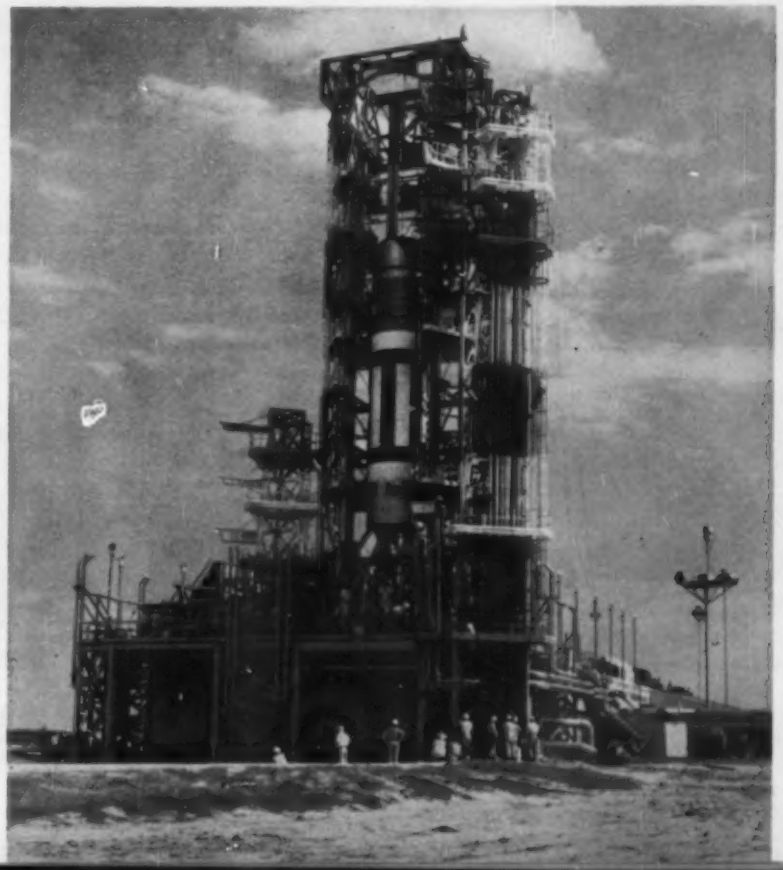
It is anticipated that programs such as the B-70 and F-108 would be shifted to some type of fixed-price contract as soon as circumstances permit. Fixed-price contracts probably will be possible earliest at lower subcontract tiers and for relatively standard items. As specifications become firmer and production experience is gained, the trend will be toward one of the various forms of price redetermination contracts, he declared.

The type of contract at the first tier



Titan Gets Systems, Facilities Checkout

Double-barreled USAF-Martin Titan intercontinental ballistic missile second stage (above) is loaded onto a gantry in a horizontal position for a ground facilities checkout at Cape Canaveral, Fla. Engines are Aerojet-General liquid propellants producing about 150,000 lb. each. Each test series has a missile used for facilities checkout and another for a systems checkout. Below, the Titan two-step gantry allows testing and static-firing of systems separately and in sequence. The gantry folds down for firing (AW June 1, p. 68) but umbilical tower at right remains erect.



XXI

This is the twenty-first of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many in this field, including men of broad experience who may find it useful to review fundamentals from time to time.

How Alloy Steels Respond to Induction Hardening

In the now-popular induction-hardening process, steel is first heated above the transformation range by means of electrical induction, then quenched as required. Special equipment is needed, and heat is developed as follows:

High-frequency alternating current passes through a coil or inductor, with the result that a magnetic field is created in the coil. When the piece to be treated is placed in this field, it is heated rapidly by induced energy. With the various types of induction-heating equipment, the process is capable of surface- or case-hardening to various controlled depths; however, through-hardening can be obtained with certain alloy steels. Ferrous metals that respond well to induction hardening include numerous grades of both alloy and carbon steels, as well as hardenable stainless steel and plain or alloyed cast iron.

As a rule, when alloy steels containing no carbide-forming elements are heated by induction, the usual hardening temperatures can be used. But with alloy steels that do contain such carbide-forming elements as chromium, molybdenum, and vanadium, the hardening temperature must be increased if shallow cases are required and the normal effect of the alloying elements is desired.

Hardness obtained by the induction process is a function of the carbon content and prior structure, just as it is when conventional heating methods are used. Nevertheless, higher surface-hardness values for a given carbon content have often been noted in parts subjected to surface induction-hardening. The extra hardness may be as much as five Rockwell C points for steels of 0.30 pct carbon.

As pointed out previously, the induction method requires special equipment. However, it possesses several marked advantages, including speed of heating and cleanliness of operation. Pieces heated by induction are usually subject to a minimum of scaling and distortion. Moreover, induction-hardening equipment is very compact and therefore conserves floor space.

If you would care to know more about the induction hardening of alloy steels, you are invited to communicate with our technical staff. Bethlehem metallurgists have made a thorough study of the subject, including the many details of quenching and tempering. Call them if they can help you in any way. And remember, too, when considering sources of alloy steels, that Bethlehem makes the full range of AISI standard grades, as well as special-analysis steels and all carbon grades.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

is determined by negotiations between seller and weapon system contractor, subject to approval of the Air Force's Administrative Contracting Officer. Air Force approval also is required as to terms, conditions, costs and profits of each procurement, either by the Administrative Contracting Officer at the prime contractor's facility or by a contracting officer at the subcontractor's facility.

In a typical subsystem competition, North American utilizes cost estimates furnished by the bidders as a basis for evaluation of the cost factor and as an element of the total cost. In the instance of competitions for airframe structural components, North American utilizes comparative rate information from the various bidders as a basis for evaluation, and projects the estimated total costs on the basis of its own calculations of the hours of efforts required. This technique is necessary, Atwood pointed out, because the programs would be delayed considerably if North American waited for the structural designs that would be required by the bidders in order to estimate the hours of effort involved.

With regard to terms of a contract relating to cost allowances covering executive salaries and other indirect costs, North American is guided by applicable government procurement regulations and directives. If an agreement already has been reached between seller and government as to the seller's rate of indirect costs, this rate is accepted. If not, such an agreement will be negotiated with the seller, subject to approval of the contracting officer.

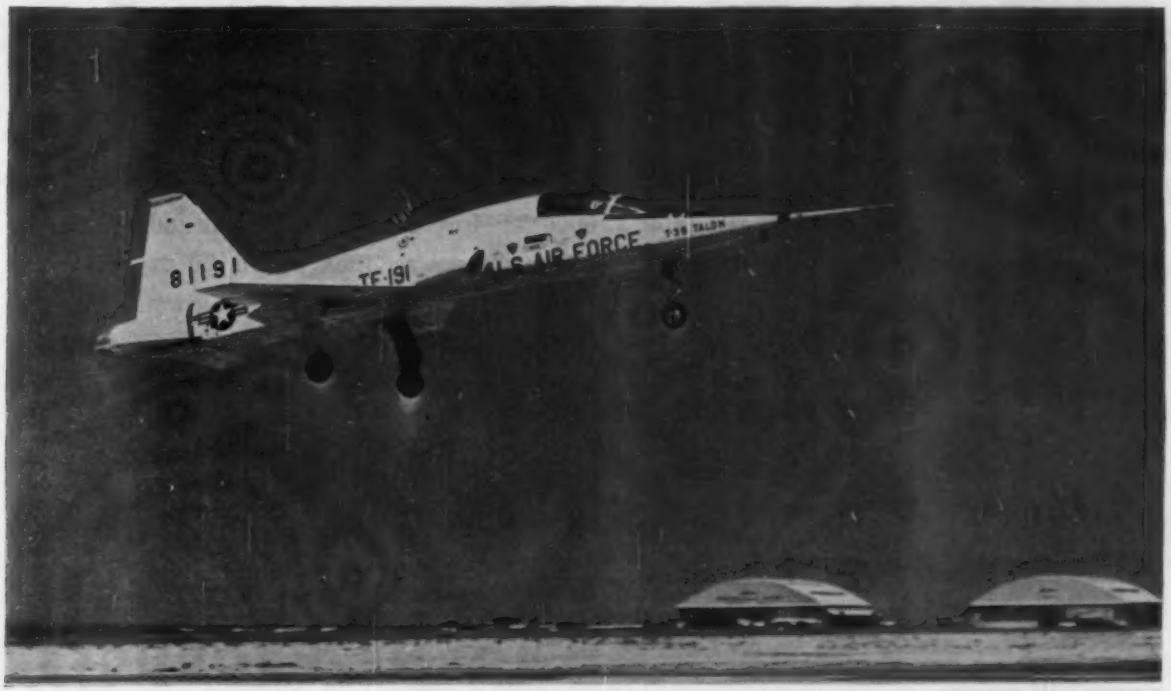
System Contracting Benefits

Some specific examples, in terms of developmental progress, offered by Atwood to illustrate benefits of weapon system contracting as applied to B-70 and F-108, included:

• **Electronic packaging.** This would be virtually impossible without the weapon system concept. Under this concept, Atwood declared, obligation does not exist to accept electronic subsystems in the particular shape and form already existing. Instead, general design of all equipment is established at the beginning to give optimum performance to the weapon system, and each contractor develops his equipment to conform to that design. In the electronic packaging concept applied to both the B-70 and F-108, all items are accessible for maintenance by means of pull-out units of a few standard dimensions. The central bay is cooled by the same environmental control system that maintains "shirt-sleeve" conditions in the crew cabin. In the B-70, the equipment is readily accessible from a central aisle for inflight repair. Many of these units have standardized, easily replaceable modules which are attached by integral plug-ins to the unit chassis. In event of a malfunction, the system has a built-in capability of discovering and indicating the faulty component, which can then be discarded, and in some instances replaced in flight with another from the stock carried on board. This electronic packaging concept, Atwood declared, will make possible a degree of reliability that is unattainable in any unmanned vehicle and higher than ever has been attained before in a manned weapon system.

• **Central air data system.** This is brought to higher refinement in the B-70 and F-108 than ever before. Without the weapon system concept, it would be impossible to make best use of central air data system, Atwood said.

• **Instrument panel** makeup to eliminate duplicative functions. There are four control and display consoles in the B-70 and two in the F-108, Atwood said. Each console has been subjected to a careful integration to combine functions wherever possible. Thus, in the pilot's console on the F-108 the various functions of the fire control and mission and traffic control systems utilize an integrated set of instruments with a single control head for channel selection and a minimum of dials and indicators. In the bombardier-navigator's console on the B-70, such varied functions as the arming of the weapon,



Northrop T-38 Talon Trainer Undergoes Tests

Northrop T-38 Talon supersonic jet trainer for U. S. Air Force lands at Edwards AFB, Calif., after completion of a test flight. Aircraft now has racked up more than 18 hr. of testing following first flight (AW April 20, p. 27). Fighter version is N-156F.

WEIGH THEM...PRICE THEM...MEASURE THEM... THEN COMPARE THEM WITH LELAND AIRBORNE'S NEW DUAL-WOUND AC-DC GENERATOR...

A single unit delivering Controlled AC and DC!

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Directly connect your DC load to LELAND AIRBORNE'S new AC-DC generator ...less weight, less space, less cost.

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terrain avoidance and station-keeping and rendezvous are accomplished through the same kind of integrated instrumentation, he said. This consolidation, repeated for other related groups of equipment, provides more efficient use of crew compartment space, saves weight and simplifies work of the crew members.

• **Common solution** of operating problems. This is another aspect of integrated weapon system development, Atwood pointed out. One example is protection against radiation. Questions involved relate to over-all shielding for equipment or use of radiation-resistant components. The best solution from the standpoint of effectiveness and weight-saving is determined for the entire weapon system, he said, and the specifications of the subsystems are drawn accordingly. Vibration presents another problem that can be solved in this manner. Vibration originating in the engine installation may be injurious to many delicate parts and assemblies. This effect is minimized at the outset, Atwood said, by locating the more delicate equipment as far from the engines as possible. With respect to the remaining vibration factor, a common solution is sought to provide an optimum design compromise, rather than leave to each design company the provision of separate vibration-proofing for its particular subsystem.

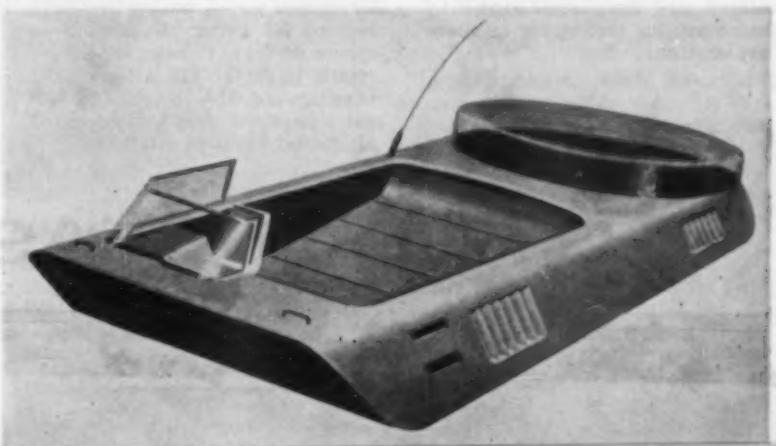
• **Cooperative development** of new manufacturing methods. Use of honeycomb sandwich material poses new brazing and welding problems, Atwood pointed out. Since these problems are common to a number of systems subcontractors, North American has established a manufacturing development program that not only applies its best engineering talent to these and similar problems but also invites the help of systems subcontractors and potential subcontractors. Thus, an improved method for constructing surface panels would be communicated to other companies which have been contracted to design and build major sections of the B-70 and F-108 structures. Specific problem in connection with a method of welding tapered metal panels was to find a means of tapering the longitudinal weld to conform to the close tolerance requirements. Atwood declared that North American's manufacturing development program has come up with an answer appearing to be a practical welding technique. This process is being passed on to the appropriate subcontractors to facilitate attainment of common objectives.

• **Cooperative testing.** North American has established a cooperative test program that brings together the various subsystems for testing at the earliest opportunity. It employs a joint test pro-

Ground Effect Vehicles Under Development

Navy ground effect vehicle designated "Skimmer," above, is tipped to show positioning of annular air jets which create a ground cushion of high pressure air under the vehicle. Compressed air is fed into the test model through hoses; air then is manifolded into the side fins. Skimmer is one of a series of vehicles under development at the David Taylor Model Basin. Primary object is to determine feasibility of very large ground effect vehicles, up to several hundred feet in diameter and which could reach up to 100 kt.

Another ground effect design is Ford Motor Co.'s Levacar shown before a trial run at the Ford Rotunda in Detroit. Company said the operator has full control over altitude and forward speed. Dr. A. W. Kucher, Ford vice president-engineering and research is in the cockpit as George W. Walker, Ford styling director, looks on. Drawing below illustrates configuration of the Curtiss-Wright Corp. Air-Car which travels on land and water using low velocity, low pressure air. Powerplant is a conventional engine with reduction gear and fan; vehicle will travel at about 30 mph. and can climb grades up to 6%. Propulsion is accomplished by releasing air through louvers located in several areas outside the vehicle; propulsion air also is used for braking action.



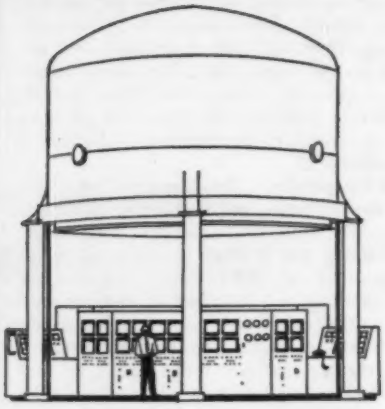
SPACE RESEARCH

The man:

...a U.S. airman-engineer—carefully selected through rigorous test procedures from Military personnel. He will have the combination of mental acuity, superb physical condition and emotional stability necessary for pioneering in space exploration.

The mission:

...satellite observatory—a vehicle arrangement similar to this could orbit a three-man astronomical crew for several weeks. Empty fuel tank is used for living quarters. Nose section serves as re-entry vehicle for return to earth. The astronomical telescope is gimbal-mounted. External equipment shown is mounted after orbit has been attained.



The means:

...Space projects are accelerated by research equipment like the Douglas high-altitude chamber at Tulsa, largest in the U.S. In it, space environment problems can be worked out under near-operational pressure conditions, shortening the time required for development.

Depend on **DOUGLAS**

The Nation's Partner in Space Research

gram in the laboratory, in cooperation with representatives of the system contractors so that two or more systems may be operated together and major inconsistencies ironed out before going to the expense of flight tests. Also, a thorough testbed program will be conducted using the Convair B-58 Hustler as the air vehicle. This telescoping of programs should permit a substantial saving in both lead time and costs, since it obviates the need to wait for completion of the F-108 or the B-70 prototypes for flight testing. To maintain surveillance over the entire test picture, Air Force has established a joint task force which will check the progress and validity of the contractor tests, provide all necessary customer aid and evaluate the operational capability which has been disclosed by the tests.

Outlining the painstaking effort in the selection of subcontractors for the B-70 and F-108, Atwood said the first step was listing qualified bidders, utilizing recommendations from North American's own organization, studying listings in trade directories, getting suggestions from various Air Force development laboratories and direct requests from suppliers. These potential subcontractors were evaluated and the list narrowed to a qualified bidders' list. In this process, North American sent out survey teams to inspect potential subcontractors in about 100 cities. Survey teams included personnel qualified in engineering, manufacturing, quality control, purchasing and industrial engineering. The teams reviewed and reported on matters such as adequacy of plant facilities, management capabilities, engineering capabilities, rejection records, cost reduction records, reliability records, geographic location and financial standing.

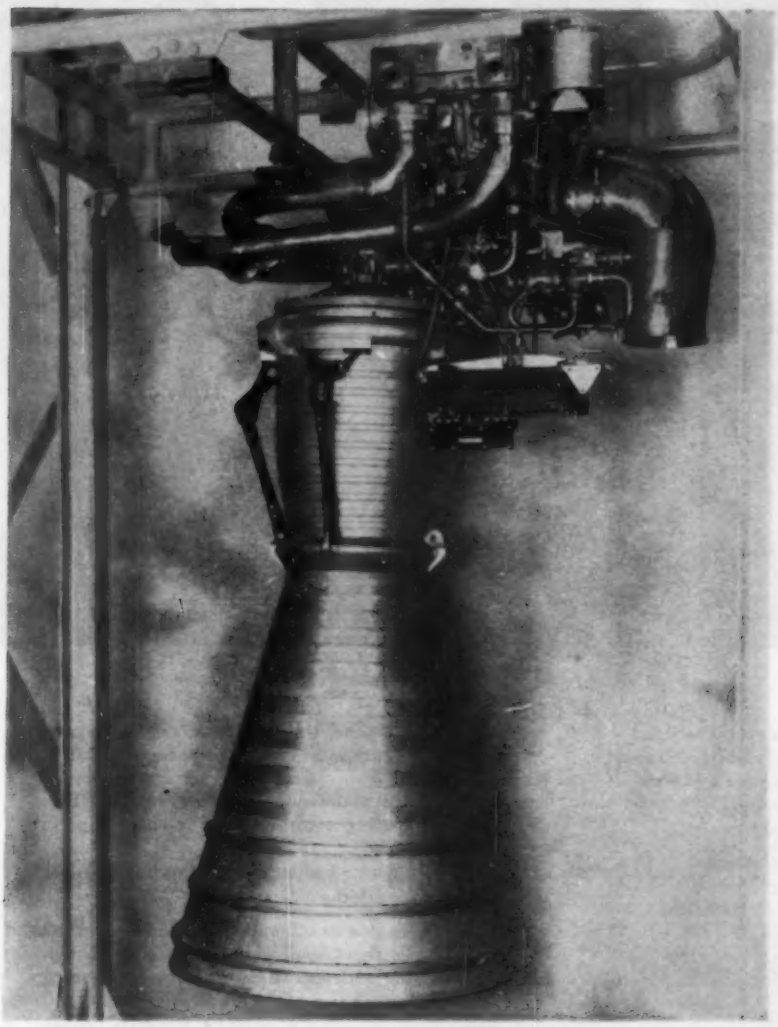
Reports were reviewed by a source selection board consisting of heads of Engineering, Manufacturing, Material, Purchasing, Quality Control, Weapon System Contracting, and Weapon System Management activity. Resulting qualified bidders list was sent to Air Force's Weapon System Project Office for concurrence.

After approval of the qualified bidders' list, bidders were called to a conference on the subsystem concerned. North American has held a total of about 30 of these conferences on the two weapon system programs, with an average of about 10 companies represented at each conference, Atwood said. The mortality rate in the early stages of the competitive process averaged about 40%—4 out of 10 companies dropped out of the competition for various reasons and did not submit bids. The total number of bids actually submitted for the major subsystems of both the B-70 and F-108 was 190, Atwood revealed, and the number of bids in each subsystem category ranged from three to 31. North American's policy, he said, is to accept a bid from every company submitting one even though it is not on the qualified bidders' list.

Proposals were reviewed carefully by individual evaluation committees qualified to judge the various key factors, including technical design, technical capability, production capability, probable cost and program management capability, involving a substantial cross-section of North American's management organization. Thus, in the evaluation of production capability of the various bidders for structural subcontractors, North American had 117 top manufacturing line supervisors and specialists working 60 hr. a week for a period of three weeks, Atwood declared.

Combined recommendations of the evaluation committees were submitted to North American's source selection board, whose choices finally were reviewed by Atwood and by various echelons of the Air Force, coordinated through the Weapon System Project Office.

In addition to North American's weapon system coordination responsibilities on the B-70 and F-108 programs, it is performing design and fabrication of about 30% of the B-70 airframe components and 35% of the F-108 airframe components. North American's Autonetics Division is developing the automatic flight control subsystems for both aircraft. This division received the business because it was ranked at the top technically and satisfied both North



Rolls-Royce Builds Blue Streak Rocket Engine

Rolls-Royce rocket engine for use in the de Havilland Blue Streak ballistic missile is being built in Britain under a license arrangement with Rocketdyne Division of North American Aviation. Similar engine is used in Thor intermediate range ballistic missile. Engine will be tested at Spadeadam, British rocket engine and missile test center.

PacAero...your finest source for complete electronics and interior installation!

As a completely integrated aircraft modification facility, PacAero is able to handle the custom installation of the electronics and radio systems, instrumentation and complete interiors of your aircraft under one roof, handled entirely by competent PacAero technicians.

So naturally, the first two Grumman Gulfstreams to be delivered to customers (Sinclair Refining Company and Harold S. Vanderbilt) are now being processed at PacAero. These new turboprop executive craft serve as excellent examples of PacAero's single-stop operation:

- **Flight instruments, radar, autopilot, communications and navigation systems and complete electrical systems are now being installed.**
- **At the same time, PacAero-designed, engineered and fabricated interiors are being constructed, custom tailored to customer specifications, to accommodate nine passengers. Space and facilities for in-flight business conferences, sleeping accommodations and complete meal service equipment are included.**
- **Complete interior and exterior painting design has been worked out with the customer.**

Only PacAero is able to offer this tremendous over-all capability – from the original sale through the equipping and servicing, with special emphasis on outstanding design and engineering.
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American's source selection board and the Air Force that it could do the job at lower cost than any of the other seven bidders, Atwood pointed out. By comparison, he mentioned that the B-70's auxiliary gyro platform subsystem was awarded to Sperry Gyroscope as subcontractor, in a competition in which the Board ranked North American's Autonetics Division proposal as fifth.

North American will have at least one resident representative at each subcontractor's plant, Atwood said, and the subcontractors in turn will have one or more at North American's facility. Through this representation technique each can be fully informed at all times concerning progress and problems of mutual concern.

Detailed milestone reporting system for subcontractors has been devised by North American to enable it to spot quickly any potential bottleneck or delay before it becomes too serious. These milestone reports, reflecting actual accomplishment against a predetermined timetable, will be supplemented by other technical reports as required by the subsystem or structural component.

Small Business

The small business program, as it relates to the B-70 and F-108 weapon system projects, was detailed by Atwood, who declared that as North American got into the weapon system prime contracting program it became apparent that its dealings with small business would include less direct contact than in the past. He advanced these reasons:

• **As weapon system** prime contractor, North American, in effect, takes the place previously occupied by Air Force procurement personnel. Past experience, he said, indicates that only a relatively small per cent of the dollar spent by the Air Force has gone directly to small business.

• **Approximately 70% of** the money spent on the B-70 and F-108 program will go to companies other than North American, including major system contractors who have a greater opportunity to deal directly with small business companies.

• **Extremely advanced** technical nature of these weapon systems dictates that most of the major subsystems can be developed and produced only by relatively large companies. It is impracticable in most instances, Atwood said, to break down an entire weapon system directly into components small enough to enable small business to compete at the first level. One of the primary objectives of the weapon system approach is to decentralize the development managerial load, he pointed out.

Because of this, greater efforts were required to assure the continued full participation of small business in these advanced weapons through the other tiers of subcontracting, Atwood emphasized. He revealed that North American has taken these steps to expand its small business policies and procedures:

• **New full-time** corporate small business administrator has been appointed, whose responsibility is working with small business in fields of research and development contracting, advise and assist small business, work with small business administrators in the company's divisions and those of the subcontractors, working with representatives of Small Business Administration, and working with small business specialists in the Department of Defense.

• **New small business** administrators have been appointed at each North American division. These men have a level of responsibility equal to that of the chief purchasing agent. They are separated from control of the buying authority but are able to coordinate their efforts with it. Division small business administrators will give full hearing to each small business supplier, Atwood declared, guide them to the area of the company where their services will be of most value, and follow through to see that the small business supplier is given equal and fair consideration.

• **New control record** has been established, which assures consideration of small business in all direct procurement by North American. This checklist must be completed by each North American buyer on each transaction, and show whether the award went to small or large business, how many small business firms were solicited, if the award went to large business, what was the reason. This checkliist was worked out in collaboration with Air Force procurement personnel, Atwood revealed, and is the first of its kind to be adopted by a defense contractor.

• **Provisions have been made** to assure

Tooling Symposium

Los Angeles—North American Aviation recently conducted a special symposium for small business firms in the field of tooling. Major subject was the role subcontractors will play on North American B-70 bomber and F-108 interceptor.

Company emphasized the concept of expansible tooling which may be used for a variety of assemblies and fabrications, permitting a higher rate of production with less cost. Ten tooling companies from this area were represented.

Veronique Gains High Altitude Data

French Veronique high altitude research vehicle, powered by liquid propellant engine, is undergoing tests at Colomb-Bechar, Africa; rocket carries 132-lb. payload to 150 mi. altitude. Veronique is 24.5 ft. long, and 2.5 ft. in diameter.

SPECIFICATION: AERONCA BRAZED HONEYCOMB STRUCTURES

DESTINATION: *MACH 3!*

To meet the critical demands of Mach 3 performance, new concepts in air vehicle structures have been evolved. Stainless steel honeycomb sandwiches, for example, are specified as major structural components in current weapons systems designed to operate in high mach environments.

Aeronca, a pioneer in the application of stainless honeycomb to air weapons, has developed advanced production methods and facilities under a proprietary research and development program. As a result, Aeronca is one of the few companies actually producing these high-temperature structures in quantity.

Aeronca is proud that its capabilities have been selected to support the North American B-70 and F-108 Weapons Systems.

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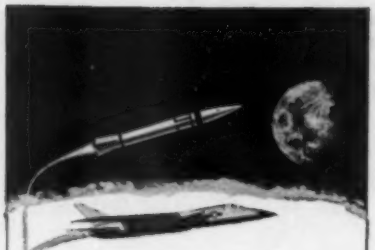
Expansion of our operations has created openings for additional senior engineers. Write to L. C. Wolfe, Chief Engineer.



Flight Control Aerodynamicists

Flight Control Systems Engineers are needed immediately to develop control systems for advanced aircraft and missile projects. Openings exist in both our Aerodynamics and Electro-Mechanical Sections.

These engineers will integrate flight control and stability augment systems with aerodynamic configuration development to obtain desired dynamic flying qualities. Experience in solving problems with five and six degrees of freedom, dynamic stability analysis, servo-analysis, feedback systems, prediction of aerodynamic stability derivatives or related areas desired.

No need to commute. Live near your job in suburban Columbus — a good place to raise your family and pursue your technical career.

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North American Aviation, Inc.
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THE COLUMBUS DIVISION OF

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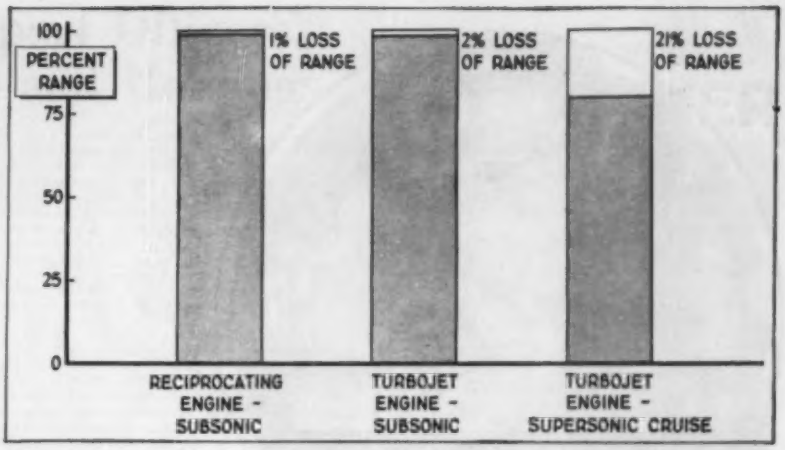


EFFECT of air inlet on bomber range assumes a 5% reduction in design efficiency.

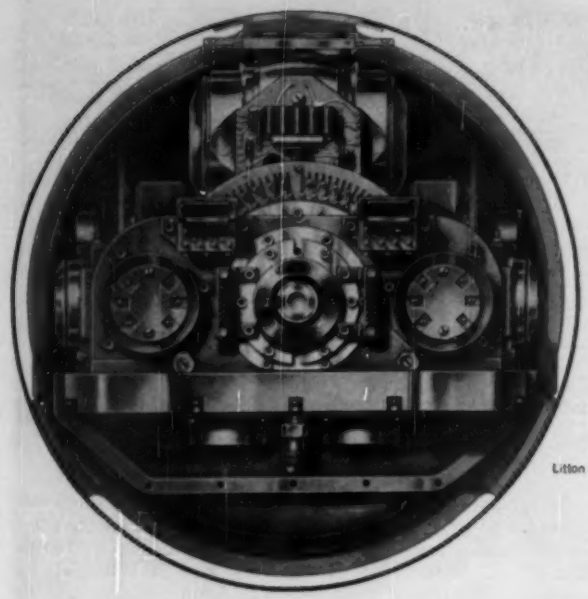
that North American suppliers establish small business subcontracting programs. In addition to the "utilization of small business clause" in North American purchase orders, additional steps provide that all purchase orders and subcontracts of $500,000 or more require the supplier to establish a small business contracting program as described in the Armed Services Procurement Regulations. Also, each purchase order or subcontract of $100,000 or more for support of the B-70 and F-108 programs requires that the supplier will furnish North American a quarterly report of all related small business subcontracts. Each supplier, in turn, agrees to insert the same provision in all of its purchase orders and subcontracts of $100,000 or more, and agrees that reports received from such subcontractors will be furnished North American.

• **Special efforts** are made to alert small business to potential contracting opportunities. All purchase orders or subcontracts exceeding $100,000 that appear to offer subcontracting opportunities are immediately reported by North American to the regional office of the Small Business Administration and to the Small Business Specialist of the appropriate branch of the armed services, so that they can alert small businesses in the award areas to the potential contract opportunities.

Estimate is that an ultimate requirement of about five million square feet of honeycomb core, costing approximately $147 million, will be required for the B-70 and F-108 weapon systems. Atwood revealed that it is anticipated that most of this business will go to companies in the small business category. Of seven companies now supplying honeycomb core to North American, six are in the small business category, he said. Another field offering substantial small business contracting opportunities is the Chem-Mill process for sculpturing metal structures.

Grumman S2F-3 Tracker Flight-Tested

Grumman S2F-3 anti-submarine warfare aircraft is latest version of the Tracker series. Fuselage has been lengthened (AW May 25, p. 37) for additional crewspace and engine nacelles are longer. Probes on wing are for flight test instrumentation. Wing tips have been enlarged and aircraft now carries improved avionic and submarine attack gear.



Litton P-200 Inertial Guidance Platform 1/3 scale

Applications of an Inertial Guidance Concept

The Litton concept of two-degrees-of-freedom gyros enables two gyros to effect three-axis stabilization of a platform for an inertial guidance system.

Some of the advantages: ***Higher accuracy because of freedom from rectification drift caused by a vibration environment.***

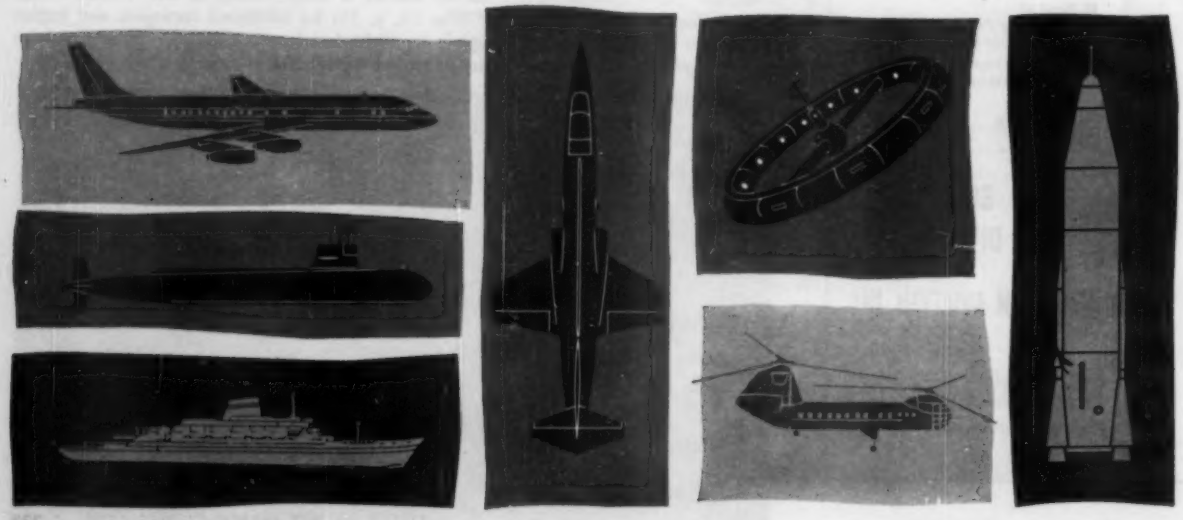
Smaller size and weight, or an order of magnitude higher angular momentum for the same weight and volume, since two large gyros fit into the same space as the three small gyros used in one-degree-of-freedom systems.

Greater reliability because of the significant reduction in complexity.

This concept and corollary concepts in the operational LN-2 Inertial Guidance System make the system fit a wide range of military and non-military applications.

Engineers and scientists who have demonstrated their ability to contribute toward further advancements in analysis, systems, development and application of inertial guidance are invited to contact Mr. C. T. Petrie, Manager, Research and Engineering Staff.

LITTON INDUSTRIES Electronic Equipments Division
Beverly Hills, California



Aircraft Firms Report Officers', Directors' Salaries and Holdings

Washington—Following is a list of aircraft company officers' and directors' salaries and stock holdings for 1958 as filed with the Securities and Exchange Commission:

Aerojet-General Corp.—**D. A. Kimball**, president and director, $35,000 salary, 210 common registrant shares and 5,175 common parent shares; **A. H. Rude**, executive vice president and director, $70,000 salary and 2,434 common parent shares; **W. E. Zisch**, vice president and general manager and director, $68,000 salary and 1,632 common parent shares; **T. E. Beehan**, secretary and director, $31,000 salary and 1,384 common parent shares; **B. I. McKenzie**, treasurer, $46,400 salary in addition to stock not listed.

F. W. Knowlton, vice president, assistant secretary and director, salary not listed with 750 common parent shares; **W. O'Neil**, chairman of the board, no salary and 17,376 common parent shares; **L. A. McQueen**, director, no salary and 13,232 common parent shares; **M. G. O'Neil**, director, no salary and 94,740 common parent shares; **T. M. Conroy**, director, no salary or stock; **G. E. Smith**, no salary with 70 common registrant shares and 165 common parent shares.

Temco Aircraft Corp.—**B. McCulloch**, president, general manager and director, $84,600 salary and 45,559 shares of common stock; **H. L. Howard**, executive vice president, treasurer and director, $65,600 salary and 21,189 shares of common stock; **I. N. Palley**, senior vice president, $45,883.31 salary with stock not listed; **D. H. Byrd**, director, no salary, 144,520 common shares and $16,000 in 5¼% convertible subordinated debentures; **J. M. Cumby**, director, no salary and 310 shares of common stock; **H. N. Mallon**, director, no salary and 3,015 shares of common stock; **O. R. Moore**, director, no salary and 58,700 shares of common stock; **H. F. Volk**, director, no salary and 45,000 shares of common stock.

Cessna Aircraft Co.—**D. L. Wallace**, president and director, $75,000 salary, 51,826 direct common shares and 20,629 common shares held jointly with family; **F. A. Boettger**, vice president, treasurer and director, $53,820 salary and 5,350 shares of common stock; **D. Hoskam**, vice president and director, $51,480 salary and 6,025 shares of common stock; **T. B. Salter**, vice president-engineering and director, $41,240 salary and 2,350 shares of common stock; **S. Coleman**, director, no salary and 945 shares of common stock; **G. McDonald**, director, no salary and 5,785 shares of common stock; **R. C. Russell**, director, no salary and 1,025 shares of common stock.

Northrop Corp.—**W. C. Collins** (deceased May, 1959), president and director, $100,000 salary, $35,000 bonus and 6,236 shares of common stock; **W. C. McDuffie**, chairman of the board, $62,500 salary and 1,000 shares of common stock; **R. B. Miller**, senior vice president, vice president and general manager—Northrop Division and director, $70,208 salary and 1,000 shares of common stock; **Dr. W. F. Ballhaus**, vice president, vice president and general manager—Nortronics Division, $52,458 salary with stock not listed.

Following directors were not paid a salary: **J. Allen**, 200 shares of common stock; **L. L. Austin**, no stock; **E. W. Carter**, no stock; **E. M. Jorgensen**, 500 shares of common stock; **R. W. Millar**, 100 shares of common stock; **J. O'Melveny**, 342 shares of common stock; **A. E. Ponting**, 110 shares of common stock; **A. C. Rubel**, 100 shares of common stock.

Avco Manufacturing Corp.—**V. Emanuel**, chairman of the board, $165,000 salary, $169,000 in 5% convertible subordinated debentures and 134,000 shares of common stock; **K. B. Wilson, Jr.**, president and director, $110,000 salary, $4,000 in 5% convertible subordinated debentures and 17,200 shares of common stock; **J. D. Shouse**, vice president, chairman of the board of the Crosley Broadcasting Corp. and director, $85,000 salary, 500 preferred shares and 11,550 shares of common stock; **Dr. L. P. Smith**, vice president, director of research planning and director, $72,500 salary and 10,000 shares of common stock; **Dr. A. R. Kantrowitz**, vice president, director of Avco Research Laboratories and director, $72,500 salary, $4,000 in 5% convertible subordinated debentures and 26,000 shares of common stock; **O. McLaughlin**, vice president, general counsel and director, $75,000 salary, $2,000 in 5% convertible subordinated debentures and 5,076 shares of common stock.

Following directors were not paid a salary: **G. E. Allen**, $2,500 in 5% convertible subordinated debentures and 2,500 shares of common stock; **I. B. Babcock**, $3,300 in 5% convertible subordinated debentures, 25

Alize ASW Plane Has Retractable Radome

French Breguet Alize 1050 turboprop anti-submarine warfare aircraft flight view shows size of retractable radome and wing slipper tanks. Aircraft will be available for export (AW April 27, p. 27) and is powered by a Rolls-Royce Dart RDa. 7 turboprop engine.

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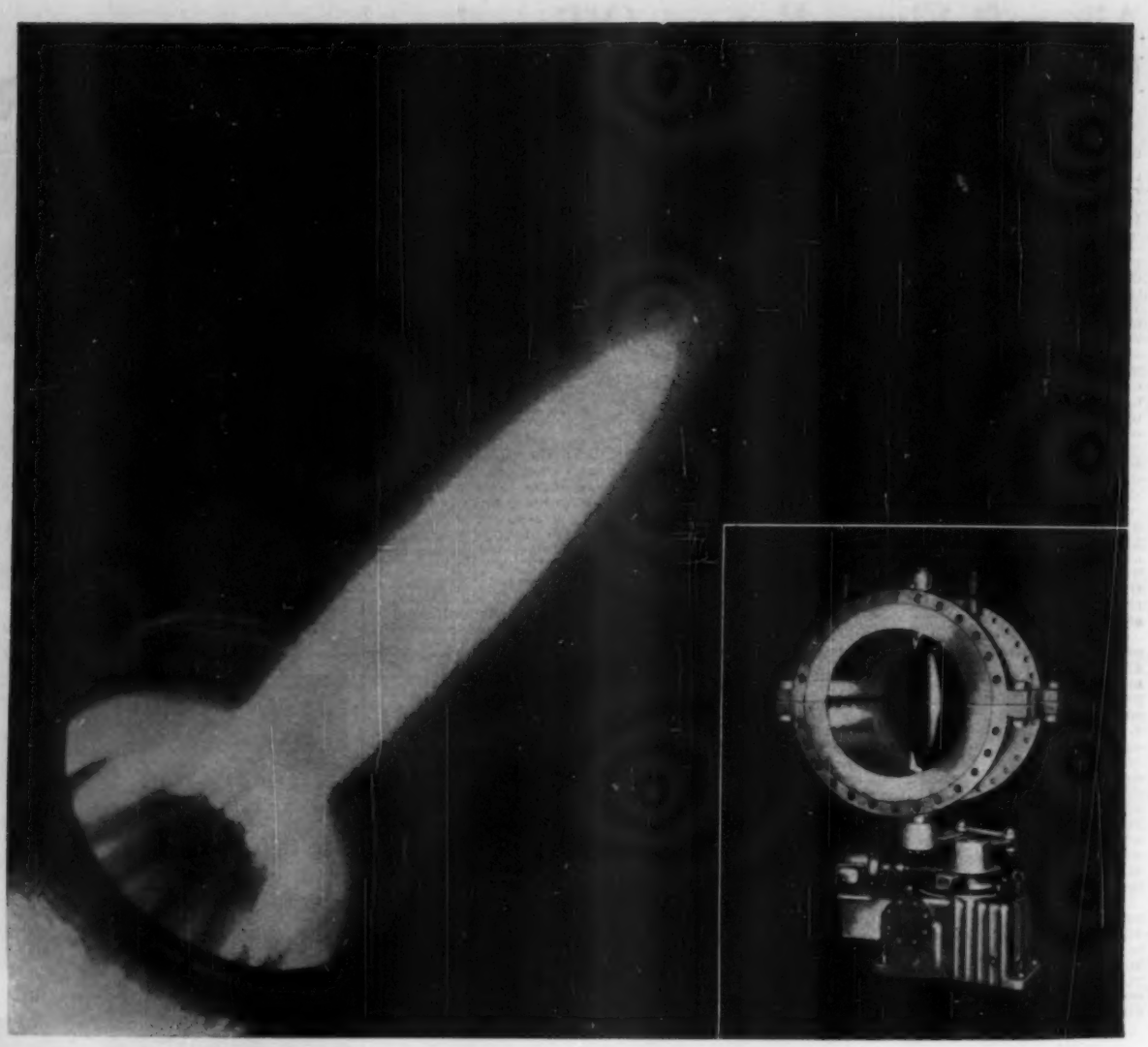

ARE HEAT AND PRESSURE YOUR PROBLEMS?

In a turbine exhaust test facility, 13-inch and 25-inch Allis-Chalmers Butterfly Valves like the one above (inset) handle gas at 2,000°F. and 180 psig. Carbon steel valve bodies and vanes are sheathed with Inconel. Each body is water jacketed, and the hollow vane, equipped with baffles, is water cooled through trunnion connections. Electric motor drive through a gear reducer provides rapid operation.

Unusual engineering is often required to relate all the factors involved in designing the best valve to solve fluid and gas control problems. If there is no precedence in your own past experience, Allis-Chalmers offers you a broad background of specialized valve engineering and manufacturing skills.

Perhaps a butterfly valve is the answer. It can be made of a number of materials to meet extreme working conditions, will give you uniform flow control through all positions in the normal regulating range. Simplified design and streamlined vanes reduce turbulence and pressure drop, help you save on power.

If you wish to find out more about how we can assist you in solving a fluid or gas control problem, contact your nearest A-C valve representative, or write Allis-Chalmers, Hydraulic Division, York, Penna.

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preferred shares and 2,097 shares of common stock; **E. H. Blaik**, vice president and director, salary not listed and 1,000 shares of common stock; **J. Bruce**, 3,000 shares of common stock; **M. W. Clement**, $2,000 in 5% convertible subordinated debentures and 1,050 shares of common stock.

C. C. Darling, $10,000 in 5% convertible subordinated debentures and 6,626 shares of common stock; **B. H. Deetjen**, $5,000 in 5% convertible subordinated debentures and 2,500 shares of common stock; **R. L. Johnson**, $1,500 in 5% convertible subordinated debentures and 900 shares of common stock; **H. H. Kahn**, 2,500 shares of common stock; **J. S. Kerr**, vice president, president-Lycoming Division and director, salary not listed, $2,000 in 5% convertible subordinated debentures and 12,000 shares of common stock; **E. H. Litchfield**, 400 shares of common stock; **J. A. McDougald**, 10,000 shares of common stock; **W. A. Morgensen**, 1,000 shares of common stock; **W. I. Myers**, $1,500 in 5% convertible subordinated debentures and 1,000 shares of common stock; **B. H. Namm**, 65 preferred shares and 1,912 shares of common stock; **T. A. O'Hara**, $4,000 in 5% convertible subordinated debentures, 235 preferred shares and 2,595 shares of common stock.

Bell Aircraft Corp.—L. Faneuf, president, general manager, chairman of the board and director, $92,962 salary, 700 common shares and 1,579 contingently allotted common shares; **R. P. Whitman**, first vice president and director, $66,061 salary and 5,975 shares of common stock; **H. Gaylord**, senior vice president, president-Bell Helicopter Corp. and director, $62,863 salary, 300 common shares and 973 contigently allotted common shares.

Following directors were not paid a salary: **J. E. Bierwirth**, no stock; **R. S. Elliot, Jr.**, no stock; **T. B. Garrett**, no stock; **P. Hufty**, 100 common shares; **A. F. Milton**, no stock; **O. A. Pfaff**, 4,800 common shares; **G. Imstead**, no stock; **J. F. Schoellkopf IV**, 400 common shares; **W. A. Yates**, 4,650 common shares; **C. S. Stuckenholt**, 350 common shares.

United Aircraft Corp.—W. P. Gwinn, president and director, $180,960.08 salary and 3,133 shares of common stock; **H. M. Horner**, chairman of the board and director, $195,760.08 salary and 10,405 shares of common stock; **E. Martin**, vice president, general manager—Hamilton Standard Division and director, $110,599.96 salary and 1,000 shares of common stock; **W. A. Parkins**, vice president—engineering, general manager—Missiles and Space Systems Division and director, $133,145 salary and 2,032 shares of common stock; **W. R. Robbins**, vice president, controller and director, $131,240 salary and 5,000 shares of common stock.

Following directors were not paid a salary: **H. S. Beers**, 120 shares of common stock; **F. W. Cole**, 704 shares of common stock; **J. D. DeWitt**, 120 shares of common stock; **O. Enders**, 589 shares of common stock; **P. M. Fraser**, 698 shares of common stock; **L. S. Hobbs**, 3,600 shares of common stock; **J. P. Ripley**, 4,200 shares of common stock; **H. S. Shepard**, 102 shares of common stock; **H. G. Stoddard**, 1,644 shares of common stock.

Thompson Ramo Wooldridge, Inc.—J. D. Wright, chairman of the board, chief executive officer and director, $148,417 salary and 13,838 shares of common stock; **F. C. Crawford**, vice chairman of the board, vice president and director, $159,875 salary and 37,384 shares of common stock; **B. W. Chidlaw**, vice president and director, $81,875 salary and 600 shares of common stock; **L. M. Clegg**, retired as vice president 6/30/58 and as director 10/31/58, $31,500 salary and no stock; **A. T. Colwell**, vice president and director, $87,750 salary and 13,000 shares of common stock; **J. H. Coolidge**, vice president and director, $88,500 salary and 15,000 shares of common stock.

H. A. Shepard, vice president, general manager of Thompson Products Division and director, $88,500 salary and 1,000 shares of common stock; **H. L. George**, vice president and director, salary not listed with 36,385 shares of common stock including joint holdings with wife; **R. P. Johnson**, vice president, general manager of Ramo

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New penetrating systems studies are underway at RCA's new Missile Electronics and Controls Dept.

Here's the perfect opportunity to take part in the most interesting of systems studies at New England's newest engineering facility! Location: Burlington, Mass.—only 30 minutes from downtown Boston. Current projects involve: weapon systems studies, aeronautical engineering, servomechanisms theory, electronic countermeasures, circuit analysis, space mechanics, infrared, electromagnetic theory.

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It's best to be where the big growth is . . . in systems studies at RCA in Burlington.

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Kelsey-Hayes is contributing substantially to the design, development and production of new thrust vector control systems for solid fuel propulsion.

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The swivel nozzle control is just one of the latest developments by Kelsey-Hayes as a subcontractor of propulsion subsystems, flight componentry and high performance materials. Spearheading Kelsey-Hayes activities is the Advanced Design Group, a flexible team of experienced design specialists. Kelsey-Hayes Company, Detroit 32, Michigan.

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Wooldridge Division and director, salary not listed with 13,907 shares of common stock including joint holdings with wife; **D. E. Wooldridge**, president and director, salary not listed with 44,630 shares of common stock including joint holdings with wife; **S. Ramo**, executive vice president and director, salary not listed with 49,154 shares of common stock including joint holdings with wife.

Marquardt Aircraft Co.—**R. E. Marquardt**, president and director, $59,907.90 salary and 32,967 shares of capital stock; **R. L. Earle**, executive vice president and director, $46,503.96 salary and stock not listed; **D. L. Walter**, vice president—Power Systems and director, $38,023.46 salary and 2,015 shares of capital stock.

Following directors were not paid a salary: **B. A. Gillies**, no stock; **H. A. Klagsbrunn**, 310 shares of capital stock; **C. B. Millikan**, 1,705 shares of capital stock; **W. H. Schwebel**, 1,731 shares of capital stock; **G. P. Tidmarsh**, 9,241 shares of capital stock; **C. E. Unterberg**, no stock; **T. F. Walkowicz**, no stock; **H. Woodward**, 2,128 shares of capital stock.

Minneapolis-Honeywell Regulator Co.—**H. W. Sweatt**, chairman of the board and director, $125,000 salary and 84,665 shares of common stock; **P. B. Wishart**, president and director, $124,897 salary and 6,360 shares of common stock; **T. McDonald**, executive vice president, assistant secretary and director, $85,000 salary and 5,000 shares of common stock; **A. M. Wilson**, executive vice president and director, $85,000 salary and 4,250 shares of common stock; **C. C. Buckland**, vice president, secretary and director, $32,500 salary and 2,137 shares of common stock.

Following directors did not receive a salary: **C. B. Sweatt**, vice chairman of the board and director, 67,680 shares of common stock; **W. L. Huff**, 19,900 shares of common stock; **C. J. C. Quinn**, 400 shares of common stock; **R. P. Brown**, 62,503 shares of common stock; **J. J. Wilson**, 40,580 shares of common stock; **D. C. Swatland**, 100 shares of common stock; **F. Maytag II**, 100 shares of common stock.

Piper Aircraft Corp.—**W. T. Piper**, president, chairman of the board and director, $35,907.88 salary, 137,344 common shares and also held 147,000 shares as trustee under voting trust agreement with sons. **H. Piper**, vice president—research and development and director, salary not listed and 23,108 shares of common stock, including stock jointly held with wife and 18,900 common shares of stock beneficially owned which is votable under trust agreement with W. T. Piper, Sr.; **T. F. Piper**, vice president—operations and director, salary not listed and 24,409 common shares, including stock jointly held with wife and 18,900 common shares of stock beneficially owned which is votable under trust agreement with W. T. Piper, Sr.; **W. T. Piper, Jr.**, executive vice president and director, salary not listed and 21,553 common shares of stock including 18,900 common shares of stock beneficially owned which is votable under trust agreement with W. T. Piper, Sr.

N. J. Greene, director, no salary and 9,100 shares of common stock; **R. E. Griffin**, director, no salary and 586 shares of common stock; **E. N. Hunting**, director, 1,050 common shares including stock held jointly with wife; **W. C. Jamouneau**, secretary, chief engineer and director, salary not listed and 315 shares of common stock; **C. W. Pool**, treasurer, salary not listed and 577 common shares, including stock held jointly with wife.

Radio Corp. of America.—The following includes director's fees and/or salary: **J. L. Burns**, president of RCA and director of RCA, NBC and RCA Communications, $160,417 salary and fees and 370 shares of common stock; **J. T. Cahill**, director of RCA, NBC and RCA Communications, $4,050 salary and fees; (Cahill is senior partner of Cahill, Gordon, Reindll & Ohl which received $425,000 for legal services during 1958), $3,500 in 3½% convertable subordinated debentures and 500 shares of common stock; **E. W. Engstrom**, senior executive vice president of NBC and director of RCA and NBC, $110,000 salary and

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NARDA Two-Stage, Low-Cost ULTRASONIC VAPOR DEGREASER

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- *Increases reliability of all engines and systems*

This new production model SonBlaster® Vapor Degreaser, originally designed by Narda for the U. S. Air Force, is now commercially available—and at low cost! Thoroughly and quickly degreases and decarbonizes: oil and fuel strainers, pistons and rings, valves, spark plugs, carburetors, pumps, bearings and parts of all types.

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Electrical Input: 208/230 volts, 50/60 cycles, 25/20 amps.

Generator: Delivers 300 watts average; 600 watts peak, 40 kc.

Transducer: Barium Titanate, 40 kc. Diaphragm, 112 sq. inches.

Recirculation System: ½ h.p. pump, stainless steel filter; 4500-watt heater, thermostatically controlled.

Valves: Pushbutton, solenoid-operated on all drains.

Cabinet: Cold rolled steel, baked enamel finish; 16 gauge, 302 stainless steel top. (All stainless steel cabinet optional at extra cost.) Over-all dimensions, 56" long x 32" high x 23½" wide.

Sumps: Over-all working area, 28" x 16", 14 gauge, 302 stainless steel, heliarc welded. Boiling sump capacity, 7 gals. Ultrasonic sump capacity, 6 gals. Distillate reservoir capacity, 2 gals.

Price: $2990 for above model. Other Narda Ultrasonic Vapor Degreasers from $1500.

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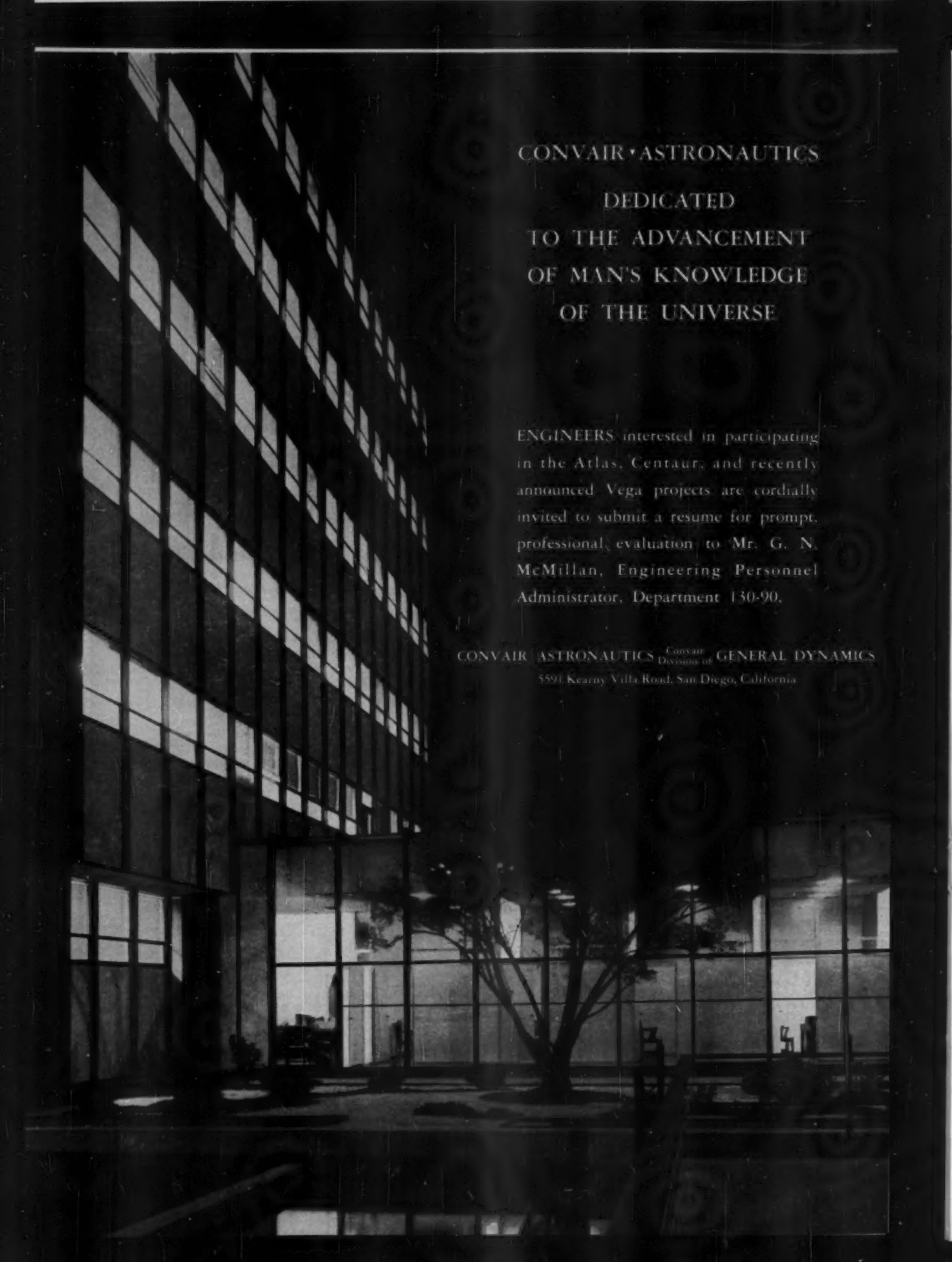

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fees, $4,300 in 3¼% convertable subordinated debentures and 1,817 shares of common stock.

F. M. Folsom, chairman of the executive committee of the board of directors of RCA and director of RCA, NBC and RCA Communications, $165,000 salary and fees and 13,682 shares of common stock; **H. C. Hagerty**, member of the executive committee and director of RCA and NBC, $16,800 salary and fees and 100 shares of common stock; **J. H. Hammond, Jr.**, director of RCA, $900 salary and fees and 100 shares of first preferred stock; **G. L. Harrison**, director of RCA, NBC and RCA Communications (deceased 3/5/58), $1,601 and no stock; **Mrs. D. Horton**, consultant to RCA and director of RCA and NBC, $6,500 salary and fees and 400 shares of common stock.

H. C. Ingles, consultant to RCA and RCA Communications and director of RCA, NBC and RCA Communications, $13,500 salary and fees and 100 shares of common stock; **C. B. Jolliffe**, vice president and technical director of RCA and director of RCA, NBC and RCA Communications, $72,500 salary and fees and 1,440 shares of common stock; **P. M. Maxur**, director of RCA and NBC, $2,300 salary and fees and 700 shares of common stock; **E. F. McGrady**, consultant to RCA and director of RCA, NBC and RCA Communications, $18,050 salary and fees, $1,500 in 3¼% convertable subordinated debentures and 200 shares of common stock; **A. Meyer**, director of RCA and NBC, $950 salary and fees and 100 shares of common stock.

C. M. Odorizzi, group executive vice president, executive vice president-sales and service of RCA and director of RCA and RCA Communications, $100,000 salary and fees and 1,502 shares of common stock; **D. Sarnoff**, chairman of the boards of RCA and RCA Communications and director of NBC, $200,000 salary and fees, $107,200 in 3¼% convertable subordinated debentures and 15,000 shares of common stock; **R. W. Sarnoff**, chairman of the board, president and director of NBC and director of RCA, $136,743 salary and fees and 855 shares of common stock; **W. B. Smith**, director of RCA and NBC, $16,500 salary and fees and 100 shares of common stock.

USAF Contracts

Washington—Following is a list of unclassified contracts for $25,000 and over as released by U. S. Air Force contracting offices:

HEADQUARTERS, OGDEN AIR MATERIEL AREA, U. S. Air Force, Hill AFB, UTAH.

Pamona Division, Marquardt Aircraft Co., Pamona, Calif., spare parts applicable to AN/APQ-T3 radar trainer and simulator group OA-209/3PQ-12T1A (IFB 42-600-59-93), $50,854.

General Tire and Rubber Co., Akron, Ohio, wheel assembly, nose, 1,704 ea., engineering data, 18 sets, technical order, 1 lot, applicable to F-86A and D aircraft, (IFB 42-600-59-172), $75,298.

McDonnell Aircraft Corp., St. Louis, Mo., modification kits, 88 ea., engineering data, 19 sets, for retrofit of F-101 aircraft, (D. O. on contract AF42 (600)-19284), $65,560.

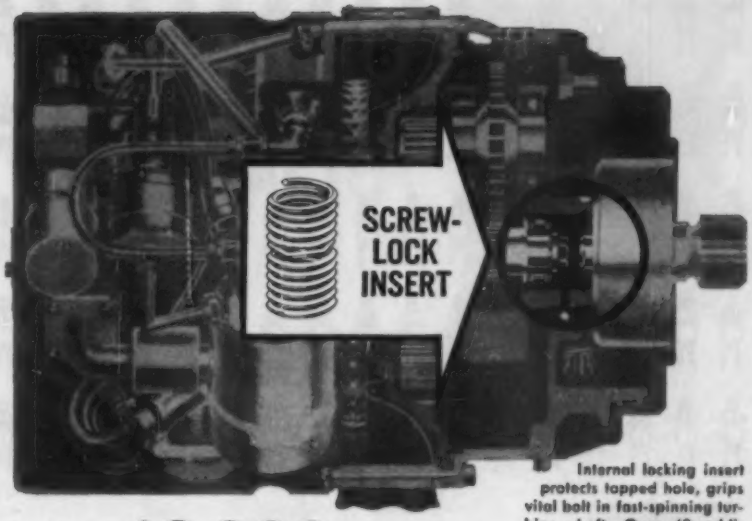
Western Hydraulics and Service Co., Inc., Gardena, Calif., spare parts and data applicable to B-66 series aircraft (PR No. 00-9-03G-2295), $58,861.

Menasco Manufacturing Co., Burbank, Calif., spare parts applicable to F-89 aircraft, (PR No. 00-9-03G-2261), $114,108.

The Reflectone Corp., Stamford, Conn., spare parts applicable to AN/UPS-T5 radar signal simulator, (IFB 42-600-59-134), $36,433.

Northrop Division, Northrop Corp., Hawthorne, Calif., repair of fair wear and tear on government furnished computer jump angle, (D. O. on contract AF42(600)-19692), 109 ea., $36,242.

Hydro-Aire Co. Division, Crane Co., Burbank, Calif., detector assembly, 753 ea., and



Internal locking insert protects tapped hole, grips vital bolt in fast-spinning turbine shaft. Over 40 additional *Heli-Coil* inserts insure threaded fastener security throughout the starter.

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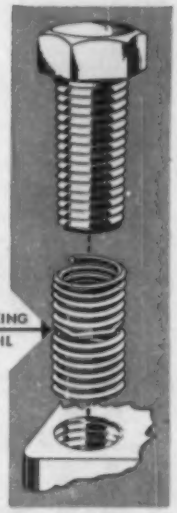
In addition to the critical shaft application, General Electric uses more than 40 of these *Heli-Coil* stainless steel wire inserts throughout this compact 165 hp starter for aircraft gas turbines. Production and performance benefits? Unshakeable fastener security *without* the use of clumsy, heavy lock nuts, lock washers and lock wiring... lighter weight... less installation cost... faster and easier assembly and disassembly of this tiny power pack that weighs only 46 pounds! *Patented



Principle of *Heli-Coil* Screw-Lock Insert. Locking center coil grips screw in tapped hole; holds screw firmly against vibration and impact.

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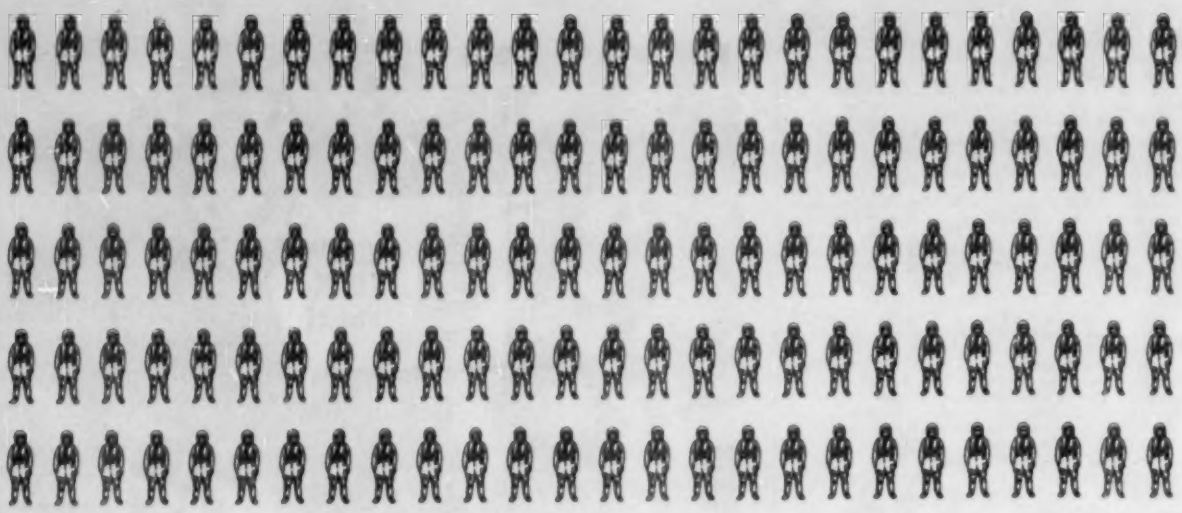
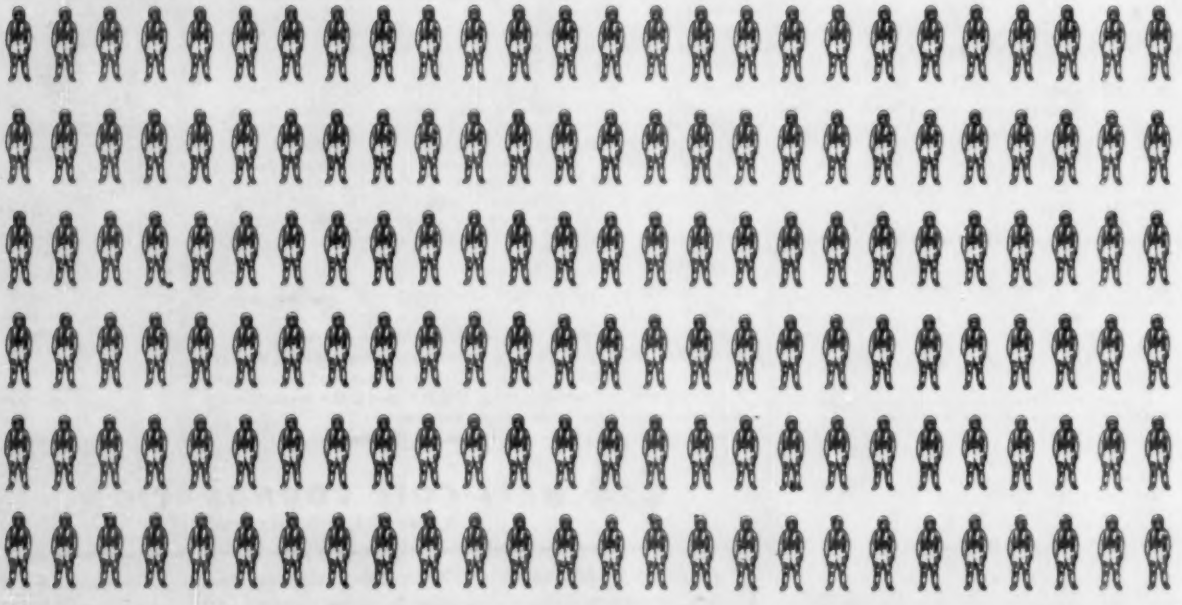


To date 286 lives have been saved by Martin-Baker Ejection Seats.



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data applicable to B-47 aircraft, (PR No. 00-9-1630-3053), $180,702.

The Cleveland Pneumatic Tool Co. Division, Cleveland Pneumatic Industries, Inc., Cleveland, Ohio, strut assembly, nose landing gear, $3 ea., and technical data applicable to F-100 series aircraft, (PR No. 00-9-03G-2213), $19,331.

B. F. Goodrich Aviation Products Division, B. F. Goodrich Co., Akron, Ohio. wheel assembly, tail, 916 ea., engineering data, 18 sets, technical data, one lot for C-47 and C-117 aircraft, IFB 42-600-59-180), $31,373.

Hydra-Power Corp., New Rochelle, N. Y., spare parts and data applicable to F-84F aircraft, (PR No. 00-9-1630-3062), $114,-119.

Pilotless Division, Boeing Airplane Co., Seattle, Wash., technical data for IM-99 missile components, D. O. on contract AF42 (600)-19572), $52,750.

AiResearch Manufacturing of Arizona Division, The Garrett Corp., Phoenix, Ariz., modification kits, 472 ea., spare parts, one lot, engineering and technical data, 6 sets, (P/L on contract AF04(607)-3380), $30,208.

AIR FORCE CAMBRIDGE RESEARCH CENTER, ARDC, USAF, Laurence G. Hanscom Field, Bedford, Massachusetts.

The Regents of the University of Colorado, Boulder, Colo., research directed toward the design and development of biaxial pointing controls and rocket-borne telemeter system, (RFP $2058), $40,756.

Shockley Transistor Corp., Palo Alto Calif., research directed toward development of new types of negative resistance diodes, (RFP 35022), $74,000.

Cook Electric Co., Chicago, Ill., design construction and test of a positive ion accelerator, (RFP 33398), $598,360.

Varian Associates, Palo Alto, Calif., magnetometers to be installed in Aerobee-Hi and Spaerobee rockets, (RFP $2009), $25,008.

Melpar, Inc., Falls Church, Va., design, construction and construction of a voice data processing system, (RFP 70451), $112,-686.

HEADQUARTERS, SACRAMENTO AIR MATERIEL AREA, USAF, McClellan AFB, Calif.

W. P. Fuller and Co., Sacramento, Calif., glass assembly armor, federal stock No. 1560-250-2726, 464 ea., $51,903.

Lockheed Aircraft Corp., Burbank, Calif., kits to improve electrical power system and install AN/AR-21 (Tacan radio navigational equipment in T-33A type aircraft (letter contract), $1,300,000.

Lockheed Aircraft Corp., Burbank, Calif., engineering and pro-typ installation of F-121 foils and training positions, progressive aircraft reconditioning to the TC-121 series aircraft, one ea., (letter contract), $100,000.

Harbor Electric Co., Inc., San Francisco, Calif., repair of generator sets, type 2C-000, 24 ea., $80,208.

Markwart Construction Co., Sacramento, Calif., remodel existing commissary and construct office and retail store facilities in buildings 70D and S-20A at McClellan AFB, Calif., $60,548.

OKLAHOMA CITY AIR MATERIEL AREA, USAF, Tinker AFB, Okla.

Peaco Products Division, Borg-Warner Corp., Bedford, Ohio, pump, centrifugal, 4832-2915-554-9865, 304 ea.; pump, rotary power-driven, 4832-2915-203-7877, 166 ea.; pump, rotary power-driven, 4832-2995-289-3377, 42 ea., (RFP OC-9-031-3-6606), $87,273.

East Coast Aero Products Division, Federal Manufacturing and Engineering Corp., Garden City, N. Y., cap, 4588-1560-560-5430, 980 ea.; cap, oil filler, 4588-1560-288-5623, 1,078 ea.; cap oil filler, 4588-1560-288-5624, 860 ea. (RFP OC-9-03F-7286), $52,821.

Boeing Airplane Co., Wichita, Kans., preproduction planning, tooling and engineering leading to the modification and maintenance of 28 ea. B-52 series aircraft, (RFP OC-9-01A-B52-12057), $500,000.

Hollywood Plastics, Inc., Los Angeles, Calif., tray, plastic, 3990-OCS-58-189, 2,000 ea., (IFB 34-601-59-345), $27,380.

Russell Plumbing Co., Oklahoma City, Okla., 171-212 flight simulator training

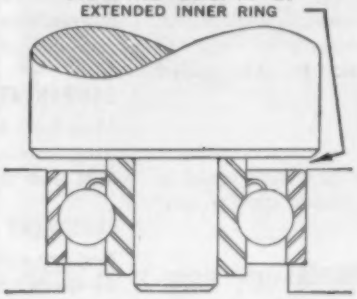
NEW HAMPSHIRE BEARING ABSTRACTS

by **A. N. DANIELS,** *President*
New Hampshire Ball Bearings, Inc.

PRICES GO DOWN AS DEMAND GOES UP FOR EXTENDED INNER RING BEARINGS

Miniature bearings with extended inners now cost less than ever before. New Hampshire Ball Bearings, Inc., has cut price additives as much as 72%. This surprising reversal of recent price trends has been made possible by production economies brought about by sharply increased demand.

This return to popularity of extended inners is not surprising to New Hampshire's design engineers. Belief in the inherent advantages of the extended inner ring prompted their inclusion in the widely distributed Technical Bulletin and Catalog published in 1956. Since then, they have been specified in increasing quantities for gear trains and other designs calling for ease of mounting, firm seating and high tolerances.



FEATURES OF EXTENDED INNERS

The above drawing illustrates the function of the extended inner. It insures clearance between the outer ring and a shoulder, a flat gear face or any other surface against which the bearing is mounted. This clearance allows the ring to revolve independently even when there are thrust loads and axial play. The importance of this clearance cannot be over-emphasized. When a small bearing is mounted to a larger element, the outer ring must not be allowed to come in contact with the larger element, or the two rings will not be independent.

This clearance must be more than just a minimum. The outer ring must have space for axial play particularly when there is any degree of thrust load involved. That's why New Hampshire Ball Bearings, Inc., extends the inner ring .0156 in. on each side. This provides ample clearance.

There are, of course, other means than extended inners to provide the necessary clearance. You can assemble a sleeve or washer on the shaft between the inner ring and the neighboring surface. Or, if the bearing contacts a gear, you can provide the gear with a hub.

However, the extended inner has two advantages over a washer or sleeve. It not only saves assembly time and cost, but also gives the bearing the firmest possible seat on the shaft.

MEET ABEC-7 STANDARDS

Moreover, the extended inner, manufactured to the same Class 7 tolerances as each and every New Hampshire ball bearing, guards against the possibility that a sleeve or washer produced less accurately may reduce the reliability of the assembly.

Complete specifications of New Hampshire plain and flanged retainer bearings with extended inner rings, with or without shields, are contained in our Design Handbook. Price quotations and delivery schedules on request.

DESIGNERS' HANDBOOK FREE TO ENGINEERS

If you work with miniature ball bearings, you'll find this 80-page, authoritative handbook contains a further discussion of extended inner ring bearings and is a great help in solving problems in designing instruments or electro-mechanical assemblies.

It will be sent free to qualified engineers, draftsmen and purchasing agents.

Write to: New Hampshire Ball Bearings, Inc.
Peterborough 1, N.H.

NEW HAMPSHIRE BALL BEARINGS, INC
PETERBOROUGH, N. H.

CIRCLE NO. 285 READER SERVICE CARD 285

a major new activity

HUGHES COMMUNICATIONS DIVISION

announces current openings

The new Hughes Communications Division is fully integrated and responsible for communications research, development, manufacturing and sales. Expansion plans are ambitious and aggressive, and the backlog of contracts already awarded, promises an expansion consistent with the spectacular records established by the other major divisions of Hughes Aircraft Company.

The establishment of Hughes as a major factor in the communications industry has created many openings for the following senior electronics engineers:

SENIOR SERVO ENGINEERS
Senior Servo Engineers are needed for the development of automatic tuning communications systems. New techniques are necessary to advance by an order of magnitude the tuning times involved. Engineers experienced in small instrument type servos, particularly memory for presetting, are ideally suited for this type of development.

ENGINEERING WRITERS
Requires HAM experience or a background in Communications Systems. Should know transistors or RF circuits.

SENIOR MECHANICAL ENGINEERS
Experience in small mechanisms, heat transfer, shock and vibration is essential.

UHF ENGINEERS
Must be experienced in the design of extremely compact transmitters and/or receivers for the 200-400 megacycle region.

SENIOR COMMUNICATIONS ENGINEERS
Senior Communications Systems engineers who have at least 7 years experience in the systems aspects of communications, are needed for assignments on the 480-L Global Communications System. This is a long term program which will necessitate offices both on the East and West coasts.

COMPONENT DESIGNER
Must have heavy experience in the design of components for airborne equipment, particularly from the weight reduction viewpoint.

EQUIPMENT ENGINEERS
Requires a familiarity with all types of communications laboratory testing equipment—uses, maintenance and procurement.

SPECIFICATION AND QUALIFICATION ENGINEER
Must be capable of directing the evaluation of ground support communications equipment.

There are a limited number of openings for non-citizens with communications experience.

For further information write Mr. Donald Horton at the address below:

HUGHES

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HUGHES AIRCRAFT COMPANY
COMMUNICATIONS DIVISION
P.O. Box 90-902, Dept. G
Los Angeles 45, California

(modify building 224, Tinker AFB, Okla., project No. OC-79-9 (IFB 34-601-59-356), $181,619.

Superior Contractors, Inc., Oklahoma City, Okla., 211-175 aircraft maintenance dock, Tinker AFB, Okla., project No. OC-76-9 (IFB 34-601-59-358), $70,471.

Lockheed Aircraft Corp., Marietta, Ga., fabrication and rework of modification kits, spare parts support and pre-production planning leading to modification and inspection and repair as needed of B-47 type aircraft, (RFP OC-9-01F-B47-12889), $368,-450.

HEADQUARTERS, WRIGHT-PATTERSON AFB, Ohio.

Rocketdyne Division, North American Aviation, Inc., Canoga Park, Calif., contract technical services, project 49-AMC-2-23, $131,500.

AC Spark Plug Division, General Motors Corp., Milwaukee, Wis., contract technical services, project 49, AMC-2-24, $151,000.

Pratt & Whitney Aircraft Division, United Aircraft Corp., East Hartford, Conn., contract technical services, project 49-AMC-2-26, $25,510.

Douglas Aircraft Co., Inc., Santa Monica, Calif., contract technical services, project 49-AMC-2-27, $170,700.

Philco Corp., Philadelphia, Pa., contract technical services, project 49-AMC-2-28, $81,950.

Defense Electronics Division, General Electric Co., Syracuse, N. Y., contract technical services, project 49-AMC-2-29, $124,-400.

Republic Aviation Corp., Farmingdale, L. I., N. Y., contract technical services, project 49-AMC-2-30, $123,400.

Link Aviation, Inc., Binghamton, N. Y., contract technical services, project 49-AMC-2-31, $52,700.

California Division, Lockheed Aircraft Corp., Burbank, Calif., contract technical services, project 49-AMC-2-32, $34,100.

RCA Service Co., Camden, N. J., contract technical services, project 49-AMC-2-34, $66,000.

Aircraft Gas Turbine Division, General Electric Co., Cincinnati, Ohio, contract technical services, project 49-AMC-2-35, $101,-300.

Gilfillan Brothers, Inc., Los Angeles, Calif., contract technical services, project 49-AMC-2-41, $62,300.

Wright Aeronautical Division, Curtiss-Wright Corp., Wood-Ridge, N. J., contract technical services, project 49-AMC-2-42, $85,800.

Nuclear Products, ERCO Division, ACF Industries, Inc., Riverdale, Md., contract technical services, project 49-AMC-2-44, $26,500.

Bendix Radio Division, Bendix Radio Corp., Baltimore, Md., contract technical services, project 49-AMC-2-45, $34,400.

Radio Corporation of America, RCA Service Co., Camden, N. J., contract technical services, project 49-AMC-2-46, $25,500.

Army Contracts

Washington—Following is a list of unclassified contracts for $25,000 and over as released by U. S. Army contracting officers:

U. S. ARMY ORDNANCE DISTRICT, Philadelphia, 128 North Broad Street, Philadelphia 2, Pa.

Western Electric Co., Inc., New York, Nike spare parts and components, DA-36-034-ORD-2388, $34,121; Nike spare parts and components, DA-36-034-ORD-2388, $38,-822; Nike spare parts and components, DA-36-034-ORD-2388, $31,635.

Research Institute of Temple University, Philadelphia, Pa., test for aerodynamic heating, DA-36-024-ORD-2328, $25,194.

Western Electric Co., Inc., New York, Nike spare parts and components, DA-36-024-ORD-2697, $102,000.

Douglas Aircraft Co., Inc., Blue Streak and emergency spare parts, DA-36-034-ORD-2582, $17,501; Blue Streak and emergency spare parts, DA-36-034-ORD-2582,

Here is a man you should know
he's a DELAVAN FUEL INJECTOR SPECIALIST

His name is Robert Ulrich. He's the Senior Project Engineer on Fuel Injector Development with Delavan. He's been with Delavan ten years, and has designed fuel injectors which are now standard on many of the world's most advanced jet aircraft and missiles. Men like Bob Ulrich, concentrating their considerable talents to fuel injector development, have made Delavan the world's largest nozzle specialist. They're the main reasons leading turbo-jet, rocket and APU manufacturers rely on Delavan for fuel injection problem solving.

If fluid metering and atomization are part of your product, take advantage of Delavan's specialized experience and proven ability to deliver aircraft quality. Send specifications to the address below for obligation-free recommendations.

DELAVAN Manufacturing Company
West Des Moines, Iowa
World's largest nozzle specialist

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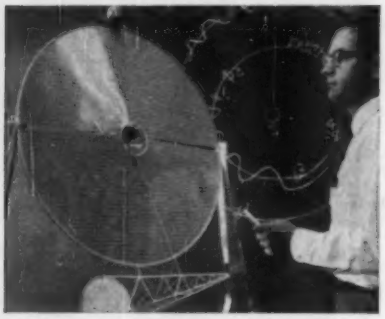
Boeing engineers work in small groups. Ability and initiative get plenty of visibility.

Test of ballistic missile propulsion system. Other tests cover space vehicle control units.



1/20th scale model of unmanned Martian reconnaissance vehicle, a Boeing study project.

Environment for Dynamic Career Growth

for Engineers and Scientists

Ability is important in getting ahead in engineering and science. But of almost equal importance is the environment in which you work. A dynamic environment that provides challenge and scope, unexcelled facilities, and plenty of room at the top, can accelerate your advance to higher levels of responsibility and income.

This is the kind of environment you'll find at Boeing... pictured and described in Boeing's new 24-page booklet, "Environment for Dynamic Career Growth."

The booklet, in addition, reports on engineering and science assignments in connection with current Boeing projects—from advanced military and commercial jet aircraft to space vehicles, guided missiles and intercontinental ballistic missiles. It also outlines Boeing research and development activities, and documents the dynamic Boeing environment that fosters career growth of engineers and scientists.

There are openings at Boeing, now, for engineers and scientists of all categories, all experience and educational levels. A Boeing assignment in Research, Design, Production or Service could be the answer to *your* future.

Mr. Stanley M. Little
Boeing Airplane Company
P. O. Box 3822-MID
Seattle 24, Washington

Please send me a free copy of "Environment for Dynamic Career Growth."

Name.....

Address.....City.....State.....

Degree(s).....

Field of Interest.....

$31,721; Blue Streak and emergency spare parts, DA-36-034-ORD-2582, $14,191.

U. S. ARMY ENGINEER DISTRICT, Omaha, Corps of Engineers, 1709 Jackson Street, Omaha, Neb.

Blount Bros. Construction Co., Montgomery, Ala., laboratory testing services, contract No. DA-25-066-ENG-5554 (IFB ENG-25-066-59-112), $37,785.

Morrison-Knudson Co., Inc., F. E. Young Construction Co., Johnson, Drake & Piper, Inc., and Olsen Construction Co., Los Angeles, Calif., construction of WS-107A-2 technical facilities, Lowery AFB, Denver, Colo., contract No. DA-25-066-ENG-5558 (IFB ENG-25-066-59-73), $40,660,034.

M. A. Gariand Construction Co., Rapid City, S. D., construction of warhead buildings, Ellsworth AFB, Rapid City, S. D., contract No. 25-066-ENG-5550 (IFB ENG-26-066-59-74, $54,949.

Joseph A. Bass Co., Minneapolis, Minn., construction of dormitories for airmen (ADC), Minot AFB, Minot, N. D., contract No. DA-25-066-ENG-5557 (IFB ENG-25-066-59-88), $735,850.

Leslie Miller, Inc., Fort Worth, Texas, construction of WS-107A operational base complex 65-3 and 4, powerplant F and E, Warren AFB, Cheyenne, Wyo., contract No. DA-25-066-ENG-5538 (IFB ENG-25-066-59-83), $532,450.

Malan Construction Corp., New York, construction of WS-107A operational base squadron 1, sites A, B and C, Offutt AFB, Neb., contract No. DA-25-066-ENG-5535 (IFB ENG-25-066-59-49), $12,870,000.

U. S. ARMY ENGINEER DISTRICT, Mobile, Corps of Engineers, 2301 Grant Street, Mobile, Ala.

A. M. Williams & Sons, Inc., Panama City, Fla., construction of jet engine test cells at Tyndall AFB, Fla., contract No. DA-01-076-ENG-4549 (IFB ENG-01-076-59-76), $55,294.

Robert A. Fleming Contractors, Inc., Panama City, Fla., construction of global communications facility at Tyndall AFB, Fla., contract No. DA-01-076-ENG-4547 (IFB ENG-01-076-59-66), $538,930.

Maurice H. Connell & Associates, Inc., Miami, Fla., architect-engineer services in connection with criteria for IRBM launch complex at Island J, contract No. DA-01-076-ENG-4550 (negotiated), $70,000.

J. I. Lark Construction Co., Panama City, Fla., construction of drone target facility at Tyndall AFB, Fla., contract No. DA-01-076-ENG-4551 (IFB ENG-01-076-59-79), $247,743.

Navy Contracts

Following is a list of unclassified contracts for $25,000 and over as released by U. S. Navy contracting offices:

AVIATION SUPPLY OFFICE, 700 Robbins Avenue, Philadelphia 11, Pa.

Master Specialties Co., Los Angeles, Calif., actuator assemblies; for automatic parachute release, N383(17)(383)59154A(PREN-11-2206/59), $36,482.

Aircraft Equipment Division, Consolidated Diesel Electric Corp., Stamford, Conn., relays: power to support NC7B units N383-58925A(383-261038/59), $217,250.

Pesco Products Division, Borg-Warner Corp., Bedford, Ohio, filter assemblies: to support pumps on various aircraft engines, N383-59222A(383-256274/59), $34,289.

Gentex Corp., New York, harnesses: parachute chest type, N383-59171A(IFB-383-650-59), 2,725 ea., $50,004.

Engine Accessories Division, Parker Aircraft Co., Cleveland, Ohio, valve assemblies: to support J65-W18 engines, N383-59112A (383-256214/59), 138 ea., $116,767.

Northeastern Engineering, Inc., Manchester, N. H., frequency meters: to support airborne radio communication equipment, N383-59091A(CG-44, 208-B), 50 ea., $75,000.

Air Cruiser Division, The Garrett Corp., Belmar, N. J., life preservers: underarm pneumatic for children and infants, N383-(MIS) - 59191A(MIPR - 09-603-9-4220-118), 2,000 ea., $43,300.

AMC Contracts

Wright-Patterson AFB, Ohio—Following is a list of unclassified contracts for $25,000 and over as released by the Air Materiel Command:

Lockheed Aircraft Corp., Burbank, Calif., F-104D aircraft, handbooks, technical data and revisions, (PR TI-9-1510-7323), $9 million.

Bell & Howell Co., Chicago, Ill., printer, contact photographic, model DC, end use; ground support equipment, (PR MO-9-6740-1711), $89,270.

Fletcher Aviation Corp., Rosemead, Calif., integral tank and pylon assemblies, 450 gal. capacity for F-105 aircraft, (PR EM-9-03L-6254), $585,393.

Kollsman Instrument Corp., Elmhurst, N. Y., components of MD-1 automatic astro compass, Aerno's 60-1225, (1'45's PE-9-05A-4217 and PE-9-05A4276), $850,000.

Ampex Corp., Redwood City, Calif., five ea., Ampex FR-114R recorder/reproducers and miscellaneous components, (PR 913224-A), $142,300.

Hewlett-Packard Co., Palo Alto, Calif., six ea., generators, HP626A and six ea., generators, HP628A and miscellaneous equipment, (PR 913236-A), $39,128.

Chromecraft Corp., St. Louis, Mo., 3,462 ea., intervalometers, used with launcher rocket, LAU-3/A, (PR 00-9-1340-2783), $25,826.

Republic Pictures Corp., New York, 277 ea., color release prints and 250 black and white release prints of the film entitles, "Vertical Frontier", SEP 644, RFP 33-600-59-5048, (PR EM-9-PP-6294), no value given.

Douglas Aircraft Corp., Long Beach, Calif., removal and preparation for shipment of excess facilities, (PR PB-9F-9043), $46,-000.

Buckeye's

COMPLETE LINE OF REFUELING EQUIPMENT FOR . . .

OVERWING REFUELING

No. 9162 high capacity nozzle features easy opening, soft closing, minimum shock, during refueling operations. Also No. 8385 Non-Drip oil nozzle for delivering lube oil. Features sure shut-off, non-drip valve in end of tube.

No. 9162 Overwing Nozzle

UNDERWING REFUELING

No. 4092 valve is easily connected to aircraft fueling adapters. Makes a positive, leakproof connection. Basic mechanism designed to deliver 600 g.p.m. at pressure drop of 8 PSI through valve and adapter. Several different models available.

No. 4092 Underwing Nozzle

HYDRANT SYSTEMS

No. 13200 Emergency Shut-off valve can be remotely controlled. Adapter poppet valve and emergency shut-off valve work independently of each other.

Also No. 4096 series standard hydrant adapters; No. 4093 series hydrant coupling valves.

No. 13200 Hydrant Emergency Valve

BUCKEYE IRON & BRASS WORKS
DEPT. AW, BOX 883, DAYTON 1, OHIO

Please send complete information on Buckeye aviation refueling equipment to:

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Title _____

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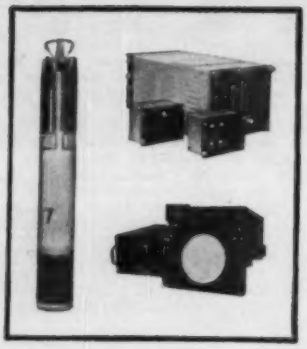
AN ASW SYSTEM... DISPLAY/AIRBORNE RECEIVER/SONOBUOYS

Anti-submarine warfare equipment designed, developed and produced by *The Magnavox Company*, in conjunction with the Navy Department, provides patrol aircraft with eyes that see underwater by day and by night. The AN/ASA-16 Display System, together with SONOBUOYS, AN/ARR-26 Receiver systems and other associated equipment provide aircraft with a clear picture of the ocean-depths below them. They are part of the continuing contributions of *The Magnavox Company* in aiding the U.S. Navy to combat the growing submarine menace.



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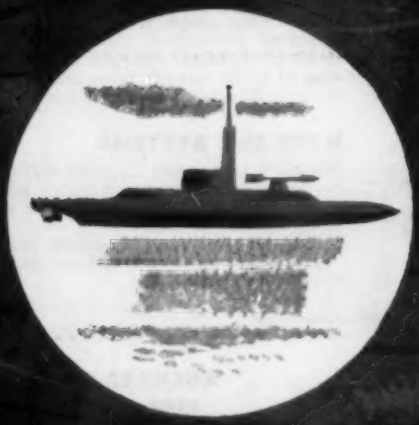

COMMUNICATIONS | RADAR | DATA HANDLING | ASW | MISSILES

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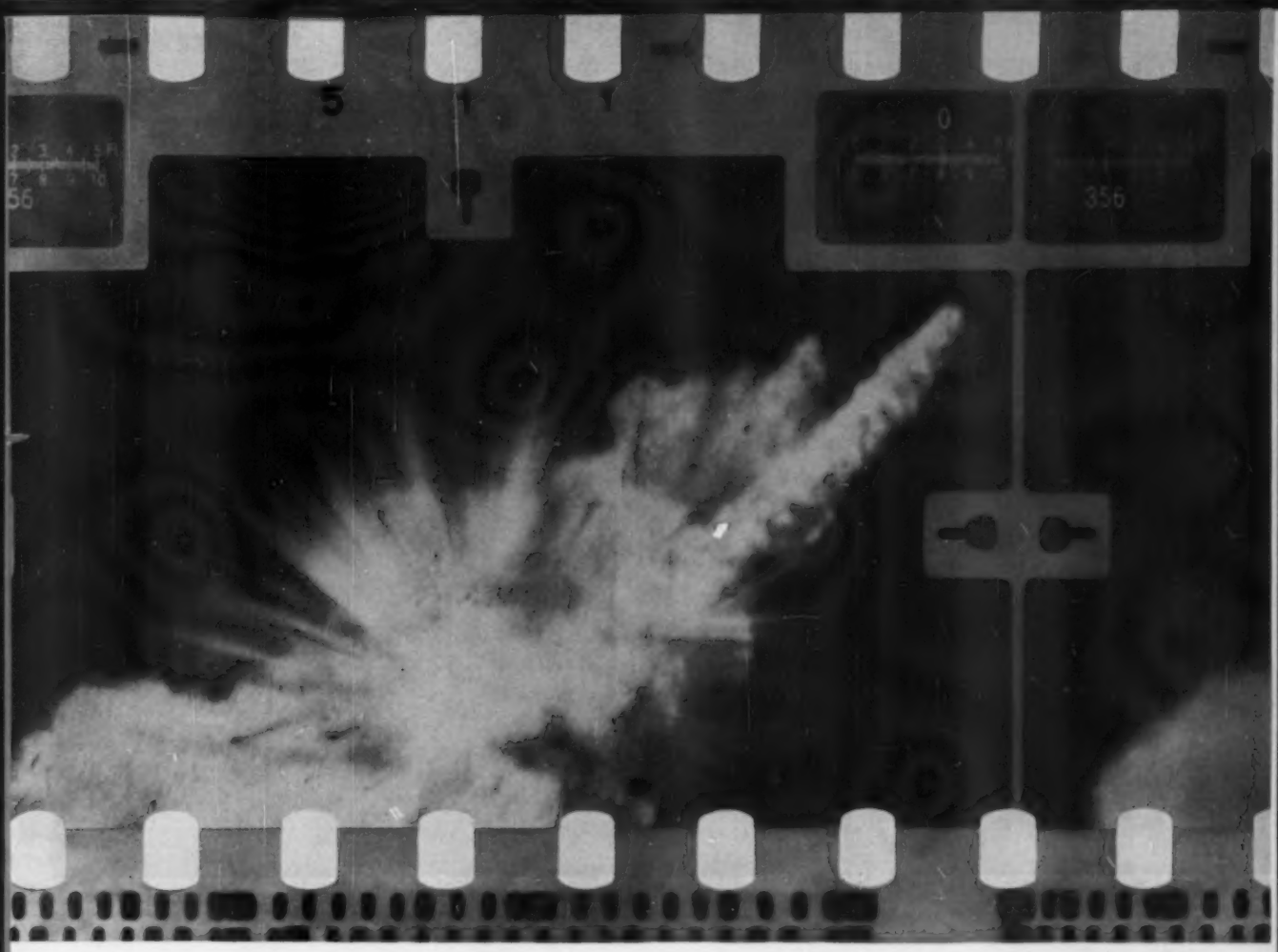


WHEN TIME STANDS STILL AT THE CAPE

Only seconds from the launching pad, the huge bird swerves from its course. The hand of the range safety officer reaches for the destruct button. There is a blinding flash as the missile disintegrates.

A failure? Yes. But a dramatic success as well. For the vital information recorded from this brief flight will contribute to the safety of the nation's first adventurer in space.

In the range control room engineers literally stop the clock as they search back through time to determine the cause of failure. Thousands of details of launching and flight have been recorded on film, chart and tape...time coded to the millisecond by Electronic Engineering Company instrumentation timing systems.

At the Cape, Electronic Engineering Company timing equipment comprises the bulk of the Atlantic Missile Test Range instrumentation timing system complex which has been in operation since 1951. The system feeds special pulse signals and binary time codes to instrumentation sites at the Cape and to down-range stations 24 hours a day, 365 days a year with negligible down time and with a time stability of one part in 10^7.

In the west, EECO has supplied the timing equipment for the Naval Air Missile Test Center Sea Test Range which has now become part of the Pacific Missile Range.

This background in producing timing systems has resulted in the development of techniques such as packaged circuitry which enables components and systems to be built quickly and more economically. A recent example: Design, development and production of seven complete dual central timing systems with 31 terminal timing units in a four-month period. Each of the dual systems supplies accurate pulse rates and binary time code words with a time stability of better than one part in 10^9 per day.

For more details on EECO instrumentation timing systems, write W.R. McQuiston, Sales Manager, for data sheet TAVW.

Several important career opportunities have just opened up in EECO's engineering department. For further information, call or write Merl Perkins.

Electronic Engineering Company *of California*

1601 East Chestnut Avenue, Santa Ana, California

RANGE INSTRUMENTATION SYSTEMS • DATA PROCESSING SYSTEMS • MISSILE FACTORY ON-LINE CHECK-OUT EQUIPMENT • NON-DEFENSE SYSTEMS • COMPUTER LANGUAGE TRANSLATORS

HUMAN

AVIATION WEEK editor Russell Hawkes writes on clipboard to check efficiency of arm and glove movements. Glove fingers (right) are of convoluted fabric with nylon tapes down the sides for restraint.

Fit, Flexibility, Heat Control Are Vital

MICROPHONE for intercommunications is hung around neck. Upper section of suit is bolted to lower section at diagonal attaching flanges running from left shoulder to right side.

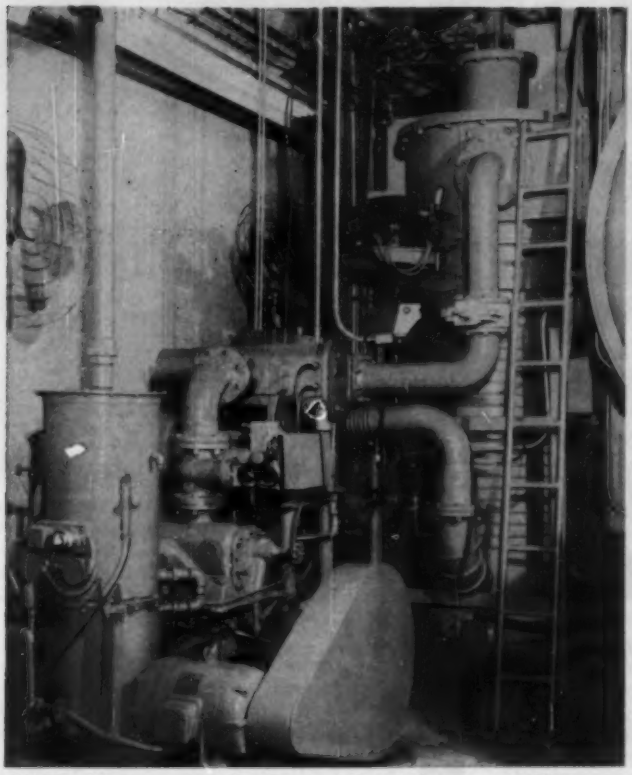
Russell Hawkes of AVIATION WEEK's *Los Angeles bureau recently spent two hours in a vacuum chamber at Litton Industries under conditions that might be comparable to those faced by a future space traveler. His account of the experience follows.*

Los Angeles—As manned space flight approaches reality, science is studying a new type of pressure suit—one intended not as protection against emergencies, but as clothing in which to walk about and do manual work in the near-perfect vacuum of space.

Such a suit will be needed for lunar exploration and maintenance of spacecraft on long flights. Litton Industries of Beverly Hills believes it has the prototype operating in the laboratory (AW Oct. 14, p. 62) and is proposing further development to National Aeronautics and Space Administration.

AVIATION WEEK's first-hand experience of the difficulties of living and working in a vacuum in Litton's space chamber demonstrated that use of a space suit is a skill that must be

FACTORS



GIMBAL rings for arm are cut from single aluminum cylinder.

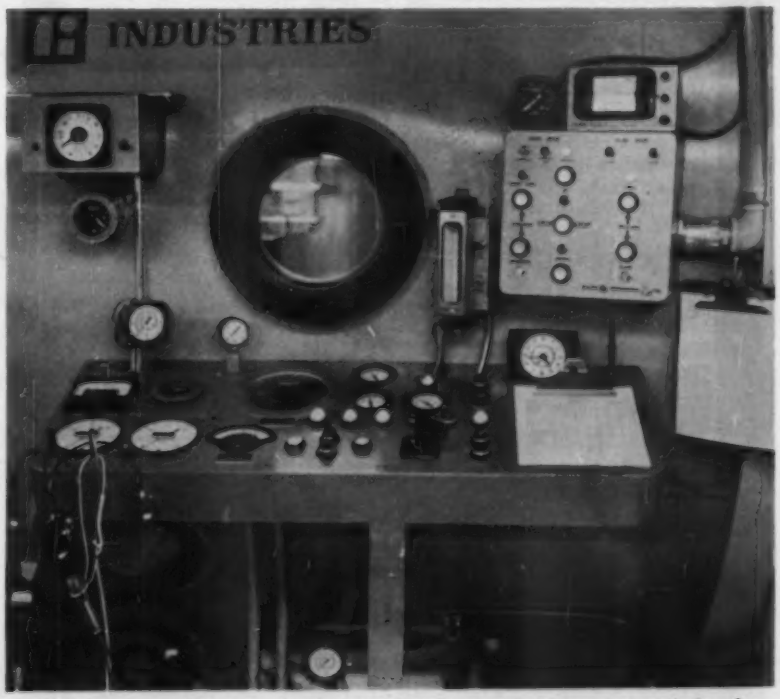
PUMPS which evacuated chamber air (left) include rotary roughing pumps at left foreground; oil vapor ejector pump and diffusion pump are at right rear. Pressure can be reduced or almost doubled by liquid filled cold plate at right. Grill condenses vapor molecules.

in Space Suit

learned like any other. Two runs were made in the space chamber, one of 1½ hr. duration at a pressure of .0014 mm. of mercury (Hg)—equivalent to a 70 mi. altitude—and one which lasted 50 min. to an altitude just great enough to keep a realistic difference between pressure inside the suit and that in the space chamber. A few simple tasks were performed on a work bench in the chamber as tests of the unusually flexible arms which are the key element in the Litton lunar suit proposal.

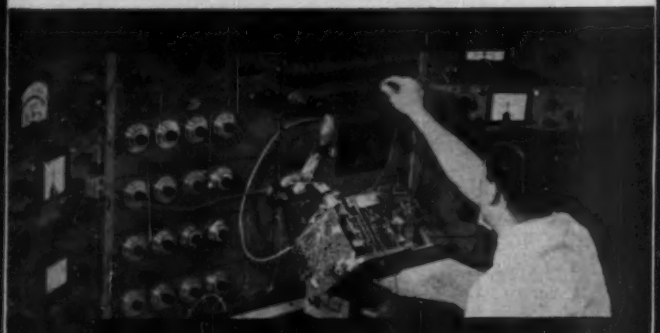
In its present form, the suit is admittedly no more than an ingenious but comparatively crude laboratory tool put together as economically as possible by Litton scientists for their own use in vacuum and also in space flight experiments.

Trousers were cannibalized from an old experimental Navy pressure suit and covered with a second pair of heavy black rubber trousers used as a vapor jacket to contain the slightest leakage which might upset the result of an experiment to be carried out in a vacuum of specified purity. The rest of



TEST director's panel includes displays of suit and vapor jacket pressure and also shows chamber and entry lock pressure in several ranges; door lock controls are at upper right.

RESOLVERS—WHEN AND HOW YOU WANT THEM AND AT MASS PRODUCTION PRICES



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Bendix

the suit was designed and manufactured by Litton personnel.

Torso and rigidly attached helmet are of aluminum to make sure there is no chamber contamination by leakage. Rubber vapor jackets over the hands and gimbal-jointed arms and the umbilical hose serve the same purpose. Rectangular aluminum ducts criss-crossing the chest evacuate the vapor jacketing on the suit. Aluminum construction and vapor jacket will be unnecessary in the planned lunar suit because leakage is too slight to be a conservation problem. Pure oxygen for ventilation and breathing enters and leaves the suit through the umbilical which passes into the aluminum belly.

In laboratory jargon, one who wears the suit is designated an "inhabitant." All inhabitants undergo a rigid physical examination which consists mainly of an uncommonly thorough electrocardiogram. An electrocardioscope is continuously monitored during the run and checked against the EKG taken in the pretest physical by the same physician who performed the examination.

Strain on Heart

Litton's medical advisors are more concerned about cardiac disturbances than hypoxia or decompression sickness because pressure altitude in the suit is held at about 27,000 ft. and the atmosphere inside is pure oxygen. The load upon the heart is undoubtedly considerable because of psychological stresses, the weight of the suit, high temperatures caused by the difficulty of getting rid of body heat when perfectly insulated by a vacuum, etc. The monitoring physicians regard the chamber runs as opportunities for research into the effects of these "hyper-environmental stresses" which are not yet well understood.

The inhabitant breathes pure oxygen from a mask for a half hour before entering the suit and while being dressed. This eliminates over 90% of the nitrogen from his bloodstream, reducing the likelihood of bends if there is a rapid pressure drop in the suit.

Two or three muscular technicians are needed to get him into the suit. A slightly modified, double-wall Air Force ventilation suit is the inner garment which distributes oxygen to the torso, legs and upper arms. Oxygen then circulates into the helmet for respiration and back out at the umbilical connection. The ventilation suit is fastened in place with ordinary masking tape and a few shallow knee-bends must be done to make sure there is no binding. Pads are taped over the shins, behind the knees and in the small of the back to keep the suit from galling.

The pressure suit itself was put on at the door to the chamber entry lock where it is usually stored. Inside the

RUBBER vapor jacket on arms is inflated by only 8 mm. of mercury (Hg.) which would be a vacuum by comparison with sea level atmosphere. Gloves would not be used in lunar suit.

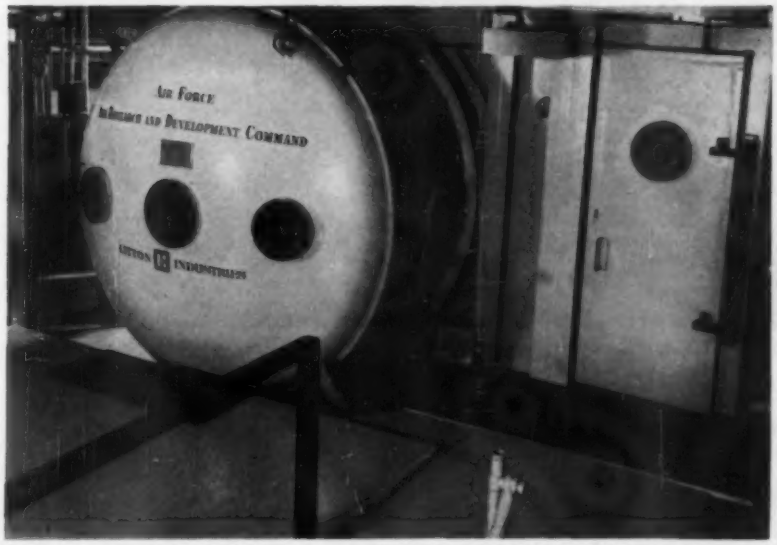
chamber, pressure was already down to .000026 mm. Hg., very close to the lowest pressure achieved that day. Pressure rises a little during the transfer from entry lock.

Help in Dressing

The lower half of the suit is stepped into like any pair of trousers, but two technicians have to hold the aluminum torso because of its weight and a third must work the stiff trousers over the inhabitant's feet. Then all three grasp the suit by the diagonal attaching flange across the chest, lift it into the air and shake it down. Bottom part of the suit includes the left arm and half the aluminum torso.

The technicians pull on the helmet and right arm and bolt it to the rest of the suit at the diagonal flange passing over the left arm and under the right arm. Communication is now possible only through the intercom and by sign language. The test director feeds room air to the suit while the helmet is being put on. After the bolts are tightened, he flushes the suit with oxygen under pressure which lifts the weight of the torso from the shoulders and makes it easier to walk. The suit weighs about 50 lb. The short walk into the closet-sized entry lock is made with a technician at each arm.

In the demonstration, about 20 min. were needed to bring pressure in the



ENTRY door to the Litton Industries space chamber is at the right. Subject is observed at all times by physicians and technicians stationed at the porthole-type windows.

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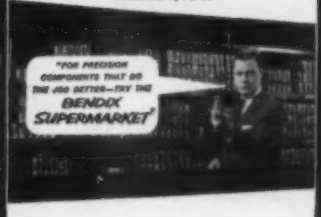
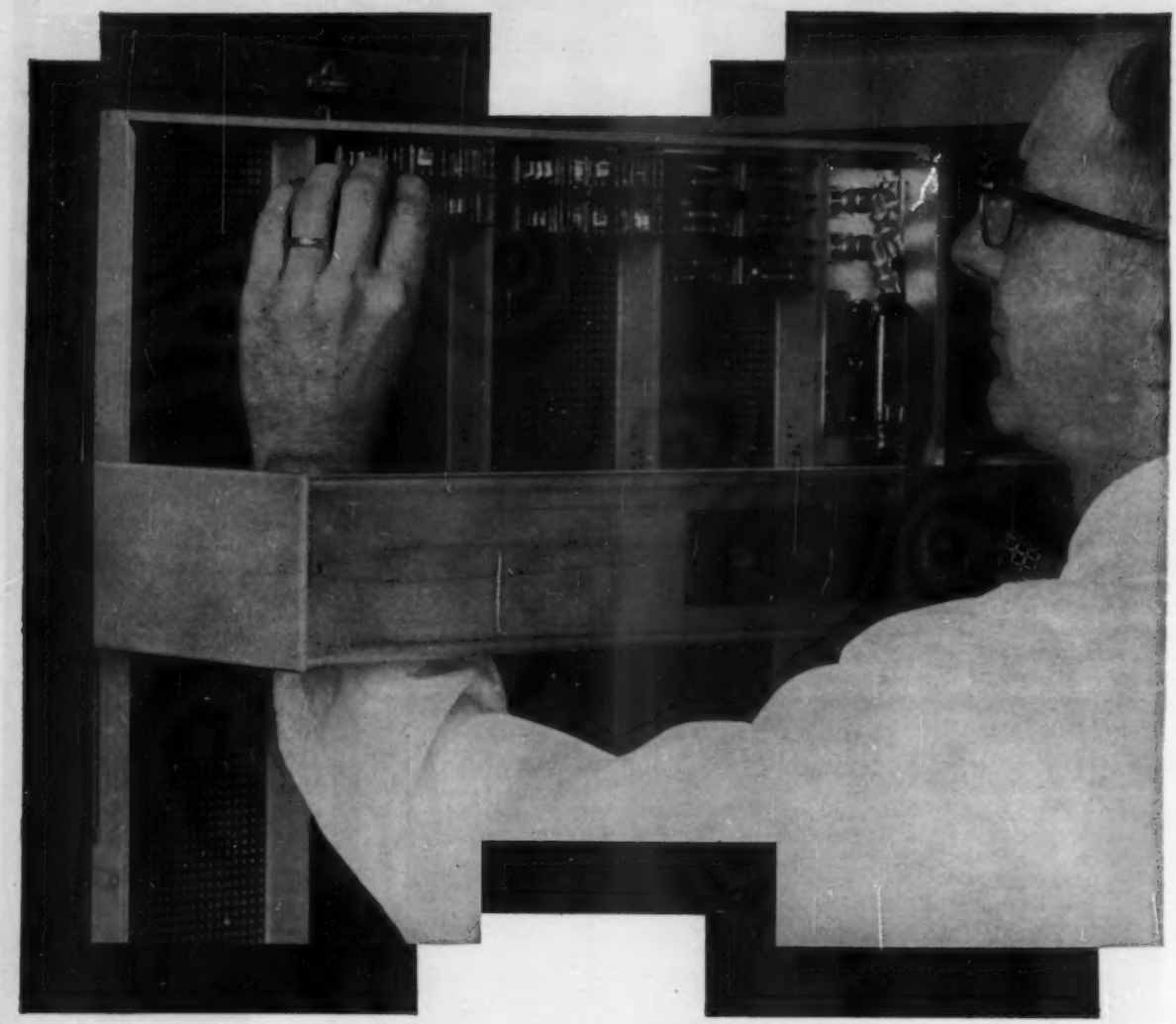


Packing circuits to circle



the world

New Electronic Scanning radar antenna—Frescanar—developed by Hughes at Fullerton, positions beams in space by electronic rather than mechanical means.

Purity Plus—Hughes Products Division engineer checks semiconductor materials to insure purity.

"Project Cordwood" is a new Hughes Communications project which has produced low-cost, widely interchangeable circuit modules *(see photo on left-hand page)*. Other projects under way at the Hughes Communications Division involve the development of systems which deflect their signals from meteors and artificial satellites. Allied to this is the Hughes adoption of the wire-wrapping technique to obtain compact, reliable and automatically applied wiring.

Because of the dynamic growth in communications, Hughes has established a separate, major Communications Division. Already, work has extended past the *transfer* of information to the *use* of information to supplement man's abilities where human resources are inadequate.

From the discovery of basic scientific knowledge through the creation of working hardware, the systems approach is typical of Hughes activities . . . in Airborne Electronics Systems, Space Vehicles, Plastics, Nuclear Electronics, Microwaves, Ballistic Missiles and many others.

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Write in confidence, to Mr. J. Melville, Hughes General Offices, Bldg. 6-A3, Culver City, California.

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units of a U. S. Navy
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U. S. policy. They came equipped to air-land Marines, win air
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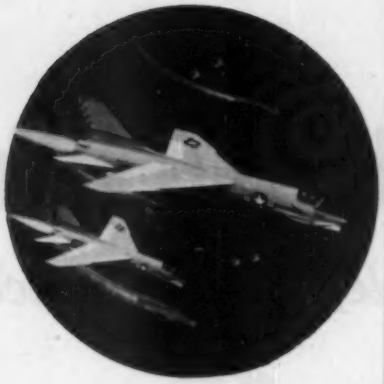

500TH CRUSADER DELIVERED TO FLEET

The jet fighter that introduced 1,000-plus-mph speed to carrier decks is now with the Navy – 500 strong. Chance Vought *Crusaders* are deployed with the Sixth and Seventh Fleets as day fighters and photoplanes. Another *Crusader* version – the F8U-2N – is being armed and equipped for near-Mach 2 combat in darkness or bad weather. It will join the Fleet next year.

With the *Crusader's* dynamic design, Vought engineers broke down barriers that have stymied carrier aircraft performance. In the same way, the Navy has tuned U. S. carrier design to the changing requirements of defense. Since World War II, these floating bases have been improved 50% in all-weather operation, 100% in aviation fuel capacity and 200% in ammunition storage.

It was a supersonic step forward when these high-performance carriers were joined by the *Crusader*. The transition was completed at low risk and cost. And these fastest of all Navy fighters have since proved reliable, serviceable and economical, too, in long periods of foreign duty that have included Quemoy and Lebanon.

Design and production of high-performance aircraft make up part of the broad spectrum of Chance Vought fields of activity. Other areas include: advanced weapons, astronautics, electronics, anti-submarine warfare, range systems management, commercial process control systems.

CHANCE VOUGHT
DALLAS, TEXAS

entry lock down to chamber pressure from the time the entry lock door was closed and dogged. When pressure in the lock dropped to 150 mm., Test Director Allan LeVantine switched over to the oxygen recirculation system, causing a slight pressure drop in the suit. At one point, all EKG leads were apparently grounded but the trouble cleared itself and pressure altitude rise was continued.

When entry lock pressure approached chamber pressure, the door between the two was cracked briefly to hasten the equalization and then opened. Almost five minutes were needed to turn and walk sideways across the bridge from the entry lock into the chamber. The distance was no more than 10 ft.

The long time needed was due partly to lack of skill in manipulating the suit and caution in a new environment and partly to the fact arms and legs of the suit had not been shortened enough. LeVantine and Litton Technical Director Siegfried Hansen, who designed the suit for their own use, are both well over 6 ft., thin and have larger hands and feet than AVIATION WEEK's editor, who does not fit this size pattern.

On the second run, the suit was better fitted and the Litton gimbaled arm lived up to its billing. All the tasks were completed without difficulty and it was possible to walk about in a relatively normal manner, partly because of increased skill with the suit and partly because each arm had been shortened by 1 in. and the legs by ¾ in.

Safety Measures

The first act on entering the chamber is to hook up to a safety cable which prevents a fall that might smash the Plexiglas faceplate. The chamber can be brought to suit pressure quickly enough to cope with almost any other type of suit rupture. A cable segment is attached to the back of the helmet before going into the entry lock with the free end hanging over the right shoulder where it can easily be grasped and snapped onto a ring at the end of the cable in the chamber. In the first run, the cable segment was attached to the helmet upside down and after some discussion with LeVantine, the run was completed without the safety cable.

Most pressure suits are tailor-made and these runs amply demonstrated the importance of a good fit. But the suits are expensive and Litton scientists believe that considerable savings can be made if lunar suits are partially standardized. Arms of the Litton lunar suit can be standardized because the length is adjustable. Something similar might be done with the legs, but torso, gloves, and helmet will have to be tailored or at least stocked in a wide range of sizes. The Litton suit

CABLE and WIRE LEADS

by HOWARD E. PENDERGAST
Technical Director Rex Corporation

Factors that influence choice of conductors

Resistance, cost, weight, tensile strength and solderability are important considerations in selecting the best conductor for an application.

Resistance is perhaps the most vital factor. The primary function of a conductor is to carry electrical energy with minimum loss. The resistance of the conductor and its insulating medium influence the degree of potential drop. Resistance is a function of temperature. Typical values for conductors at room temperature are shown below:

Material	Resistivity
Copper	1.72×10^{-6} ohm cm
Aluminum	2.82×10^{-6} ohm cm
Silver	1.62×10^{-6} ohm cm

Cost is chiefly a function of the metal used. Silver would be the obvious choice but for its expense. Copper usually combines the best cost-resistivity ratio.

Weight. Where weight is extremely important and lower conductivity is acceptable, aluminum can be considered. It is preferred for high power transmission lines, for example.

Tensile Strength — "cladding" techniques permit the combination of two metals — one for strength, the other for conductivity. Thus, copper clad steel is now popular for applications calling for high tensile strength.

Solderability is of critical importance for permanent connections. Tin coating by electro-deposition or dipping before final sizing and stranding of conductors is now universal. A growing demand for tin overcoated stranded conductors is prevalent. This offers reduced labor costs during assembly but substantially lowers flexing life and flexibility of the basic stranded conductor. Silver plating is now common with increased demand for high temperature wire. Because manufacturing temperatures are higher than the melting point of tin, silver has been selected as an aid to soldering and a protection for copper. Various alloys of nickel both as plating and cladding are under study as replacements for silver plating. Nickel's high melting point and lack of wicking promise to reduce soldering failures with high temperature wires.

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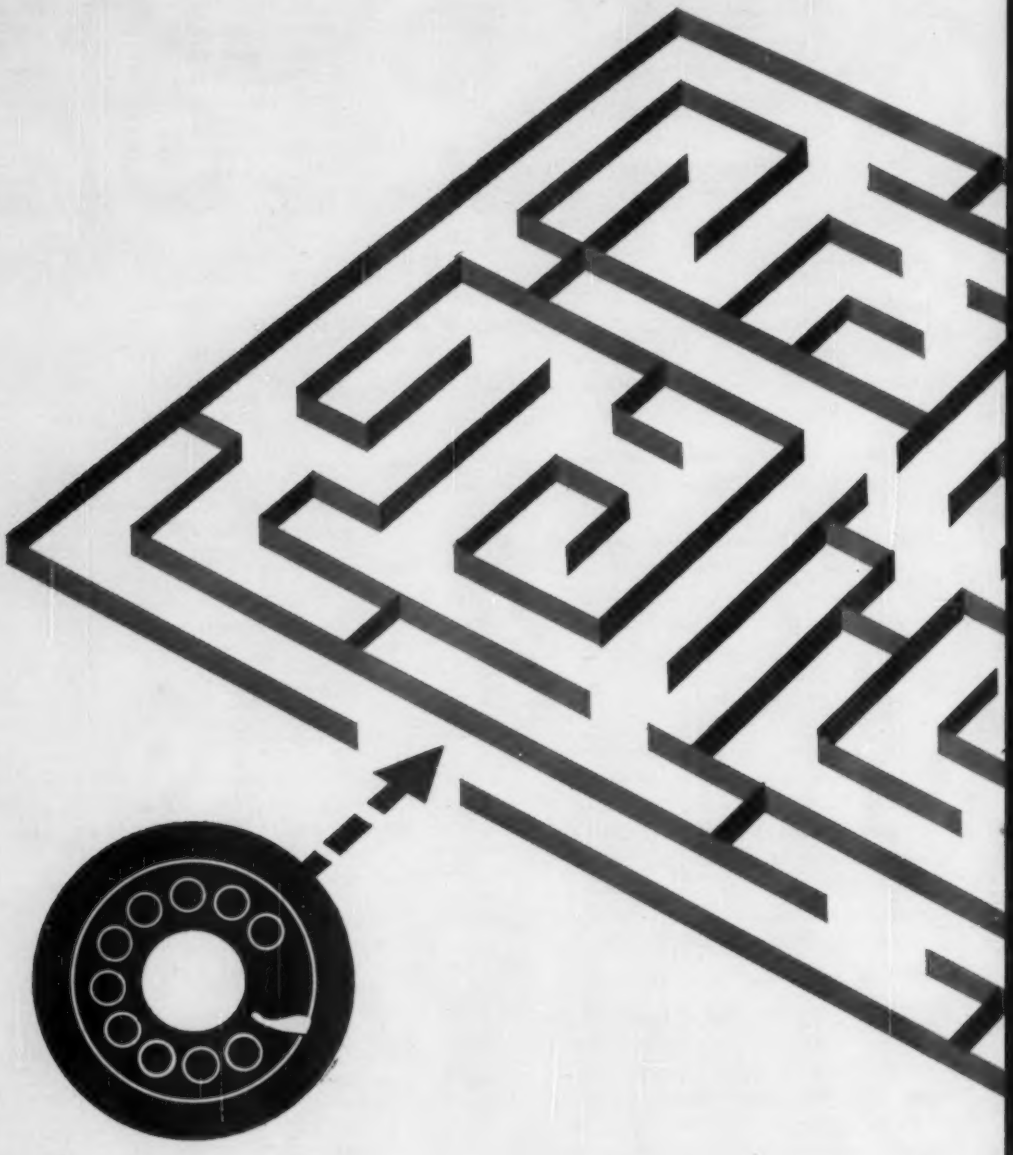
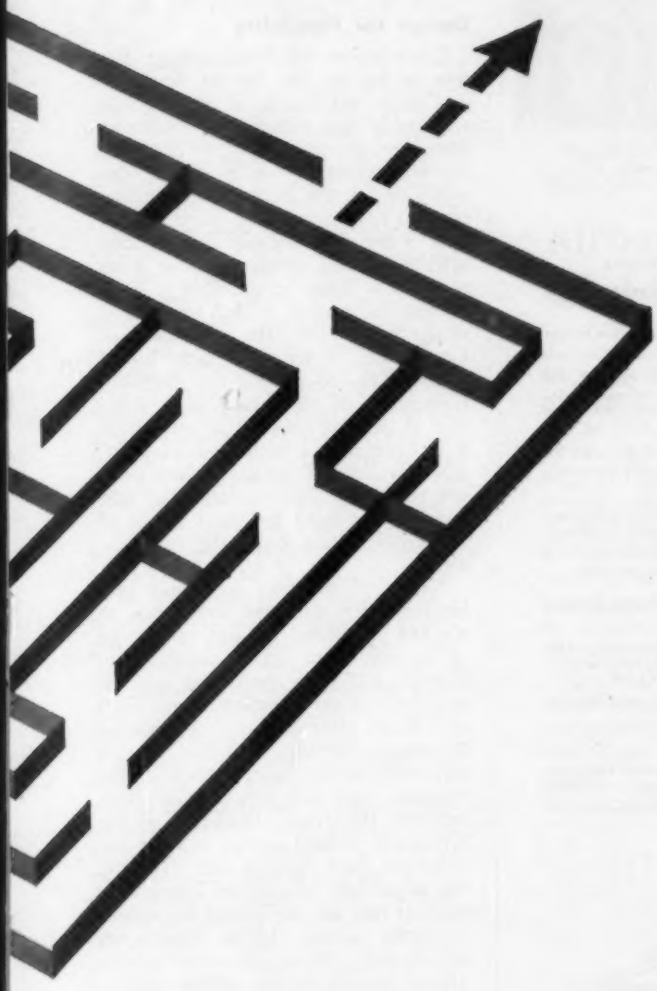
Automation cut its teeth on the

...how ITT's early work in telephony advanced



telephone

the art of automation



The dial telephone exchange was one of the first examples! Today, automatic switching and new electronic techniques for automation are altering the operations of virtually every business and industry.

It was natural that ITT System companies, pioneers in the first, should be leaders in the second.

Customers have ranged from mail-order houses, railroads, libraries and oil companies to the air forces of several NATO governments.

There have been dramatic results.

One example is the automatic check-processing system developed by ITT System companies for one of the nation's largest banks. It codes, sorts and verifies checks. It performs all normal bookkeeping and accounting operations for demand deposits.

Another is the automation system for a large steel mill which records the program of requirements for every job, then feeds back information to production control centers as each phase is completed.

Still another: the first automatic U. S. post office, now under construction in Providence, Rhode Island.

Hundreds of others could be cited. Each required a complete understanding of automation from the design of a simple switch to the functioning of a fully-integrated electronic complex.

The ITT System has many specialists in this field. Among them: Intelex Systems Incorporated in retained-document automation; Kellogg Switchboard and Supply Company in automatic switching; Airmatic Systems Corporation in automatic-switch pneumatic tube and document-conveyor systems; ITT Federal Division in automatic test equipment, both military and industrial. ITT's European subsidiaries add to this experience.

To learn more about ITT's abilities in the area of automation, write for further information.

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For full information on Airborne modular design electromechanical actuators, request Bulletin 57A (linear type) or Bulletin MR-58 (rotary).

GENERAL ENGINEERING DATA

Airborne Modular Design LINEATOR Actuator LA16-2-2

1. 115 v a-c, 400 cycle reversible motor with magnetic brake
2. Speed at normal load of 400 lb.: .2 in./sec. (max. op. load—1690 lb.; max. static load—3230 lb.). All noted loads in tension
3. Ambient temperature: −65 to +160°F. Altitude to 55,000 ft.
4. Weight: 4.4 lb.
5. Design incorporates 2 limit switches, 2 intermediate position switches, nonjamming positive stops, overload slip clutch, synchro transmitter.

Airborne Modular Design ROTORAC Actuator RD12-2-3

1. 26 v d-c, split field, series wound reversible motor with magnetic brake—capable of continuous stall
2. Speed at 20 in./lb. normal torque: 1.7 rpm
3. Weight: 1.1 lb.
4. Design incorporates 2 limit switches, 2 intermediate position switches, nonjamming positive stops, overload slip clutch.

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would probably consist of hand, arm, helmet, torso and leg subassemblies rather than be fabricated in a single piece as most current pressure suits are. This would ease the problem of assembling well-fitting suits from standard elements. The Litton suit would probably weigh more than current emergency pressure suits, since it would carry its own recirculating oxygen systems and since the gimbaled arm is somewhat heavier than less flexible designs. However, this would not be too serious on the moon where an object weighs one-sixth as much as it does on earth.

Litton scientists briefly considered putting the oxygen recirculating system in a sort of caddy cart with an umbilical to the suit much like that in the space chamber. This was quickly abandoned as it would be too much of a nuisance to wheel it around and the umbilical would be too vulnerable.

Design for Flexibility

Convolutions or folds circling the arm or leg are the key to flexibility in a space suit design. A pressure suit arm can be bent without the inhabitant doing any gratuitous work to compress the atmosphere within it if the convolutions on the inside of the elbow take up some fabric and those on the back of the elbow let out some to keep internal volume constant. Some form of restraint must be provided to keep it from inflating to its full length and straightening out the convolutions. Litton uses a series of nine linked gimbal rings to provide end restraint. Elongation of the nine-gimbal structure at working pressure is only about ⅛ in. and it will withstand an emergency overload of one atmosphere without permanent deformation. The arm can be bent until the outer radius of the elbow is six times the inner radius.

Fabric of the arm is two-ply rubberized nylon with the weave axes of the first ply rotated 22½ deg. from those of the second to tighten resistance to leakage. Fabric is convoluted over external aluminum L-section support rings at 2.88 in. intervals within the gimbal structure. Outside of fabric arm is cemented to the inner surface of the support rings and convolutions form between the rings. Diameter of the fabric arm is small enough to keep convolutions from bulging out. Instead, the fabric folds around the edge of the support ring and lies almost flat against its outer surface. Litton experts say this is more efficient than other convolutions because volume within the convolution itself is smaller so that there is less change in total volume of the arm.

Present-day emergency pressure suits are often designed with a mesh sleeve

of interlocking, non-elastic cord helices which is free to redistribute its material from one side of the arm to the other, providing the necessary endwise restraint and at least limiting variations in the arm's internal volume. This is considerably lighter than the Litton concept but it offers a less perfect control of volume. Furthermore, if a mesh cord breaks it will unravel the mesh sleeve since the cords cannot be knotted or anchored if they are to be free to slide over each other and redistribute the sleeve material.

The first set of arm gimbal rings was cut from a single cylinder of aluminum. Each ring was the product of two V-shaped saw cuts, with the vertices of the first V pointing up and the vertices of the second cut rotated 90 deg. around the cylinder and pointing down. The vertices from lobes at which adjacent rings are joined by an oblong link much like a bicycle chain link.

Arm Details

Lower forearm of the suit includes the adjustable length portion. Arm lengths range from 25.62 in. to 29 in. Above the adjustable length portion is a rotating joint enabling the inhabitant to turn his hand from palm up to palm down and back. Since the inhabitant's arm is free to turn within the suit arm, the one joint enables the whole arm to rotate. The wrist joint turns on roller bearings and is well sealed by a thin Teflon gasket.

Palm of the glove is aluminum. Fingers are convoluted fabric with nylon tapes on both sides of each finger in the plane of bending to provide endwise restraint. They are extremely flexible and can be used for writing and for reasonably precise assembly and disassembly. Finger control was better than what one might expect from ordinary heavy gloves, but it is certain that tools to be used outside the confines of a pressurized cabin will have to be engineered to compensate for some loss in dexterity. The same will be true of equipment to be maintained by space ship inhabitants if it must be reached from outside.

An unforeseen effect of living and working in the suit was a greater dependence upon vision than in everyday activities. Sense of touch responds more to resistance of the suit than to the object being grasped or touched by the glove. At first it is hard to tell how tight one is gripping an object and there is no sensory reminder of objects being held outside the visual periphery of the faceplate. At one point during the runs, a screwdriver was being held outside the field of vision when a need arose to grasp something else. The screwdriver was instantly dropped and probably wouldn't have been missed if observers

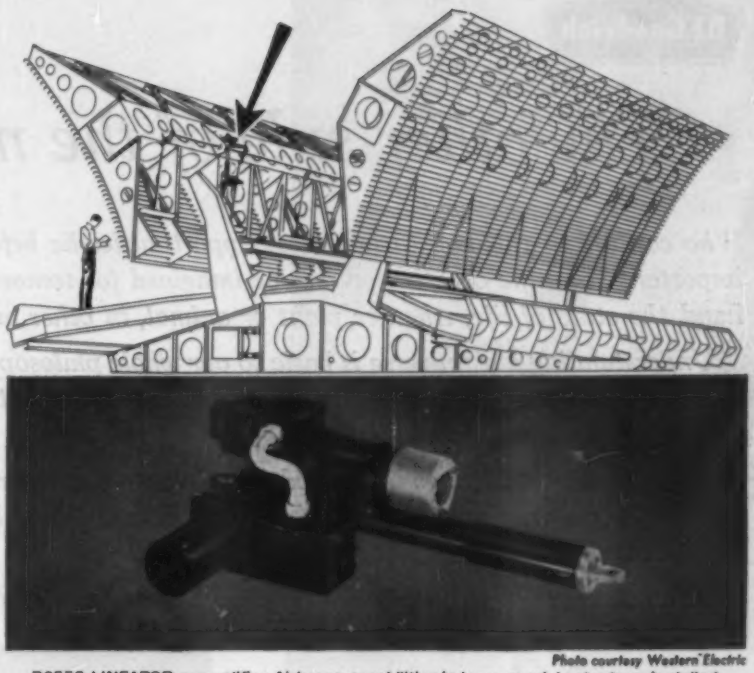

Photo courtesy Western Electric

R2552 LINEATOR exemplifies Airborne capabilities in large special actuators. Installed in pairs, units control tilt and shape of DEW Line antenna reflectors, must operate in temperatures from —65 to +130°F.

Airborne large special actuators used for DEW Line antenna control

Airborne large special actuators are being employed today in a diversity of applications, both air and ground. On the DEW Line, for example, pairs of Airborne R2552 LINEATOR actuators are used to control the tilt and shape of AN/FPS-19 antenna reflectors. Environment in this instance involves extreme temperature and humidity conditions and these call for a high order of mechanical and electrical reliability.

The R2552 typifies Airborne's capabilities in developing large special actuators—linear or rotary. And where requirements are not unique, we also offer a line of modular-type actuators, originated by Airborne to simplify design and specification. Write for further information.

GENERAL ENGINEERING DATA

Airborne Special Design
LINEATOR Actuator R2552

1. 208 v a-c, 60 cycle, 3 phase reversible induction motor with magnetic brake
2. Speed at rated load of 400 lb.: .3 in./sec.
3. Ambient temperature: –65 to +130°F. (–80°F. non-operating). Relative humidity: up to 100%
4. Design incorporates 2 limit switches and 4 intermediate position switches, plus synchro position transmitter.

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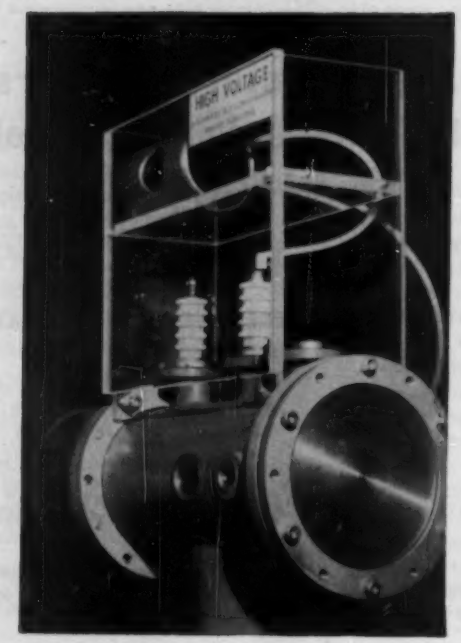
The other side of the mountain

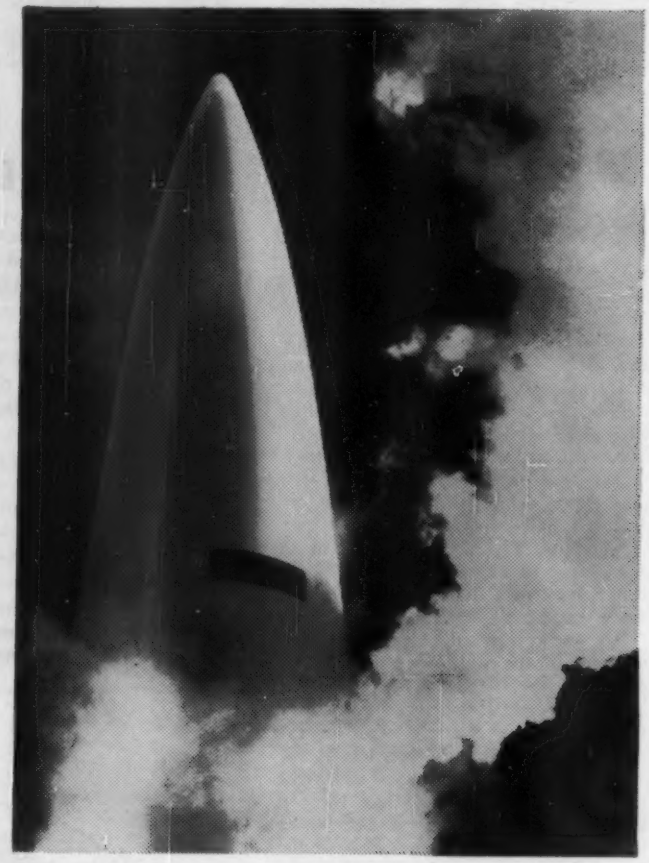
Who can tell at this stage what great opportunities lie before man in space? What more important scientific observation can be imagined for tomorrow than to confirm at first hand the state of life, whether plant or animal, in other areas of our universe?

Understanding our universe is basic to our whole philosophy of being. Man's quest of space travel is one of his noblest efforts in these times. Space is the frontier of today. It is the other side of the mountain.

During the past 25 years B.F.Goodrich has been a partner in many vital space-age projects. Some of them are shown here. Others are discussed in the booklet, "B.F.Goodrich Resources for Missile and Rocket Progress." For your free copy write B.F.Goodrich Aviation Products, a division of The B.F.Goodrich Company, Akron, Ohio.



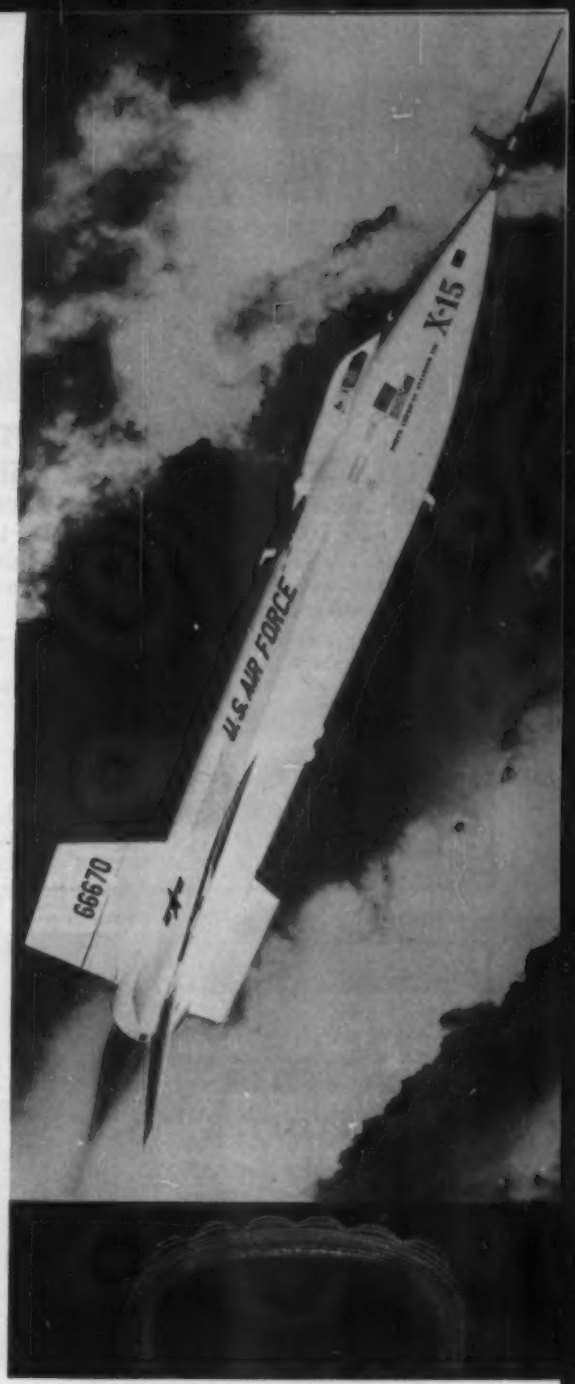
This ion propulsion device was developed by Goodrich-High Voltage Astronautics, Inc., Burlington, Massachusetts. It demonstrates the operating principle of ion engines that may send vehicles through space at speeds of more than 100,000 miles an hour.



Important B.F.Goodrich advances in nose cone fabrication —plus the use of unique new materials—are helping to solve the problem of re-entry into the earth's atmosphere. B.F.Goodrich also supplies many other important components for ballistic missile projects.

At its Rialto, California plant B.F.Goodrich has facilities for supplying complete solid fuel propulsion systems. BFG castable and case-bondable propellants have outstanding ballistic and physical properties for use in missiles of various types and sizes. The star-shaped internal configuration shown here establishes the burning program for a particular rocket motor.

Since 1934, when it developed the first stratosphere flying suit, B.F.Goodrich has helped pilots fly higher and faster. When the first man sets foot on the moon, chances are he'll be wearing protective clothing similar to this latest B.F.Goodrich Lightweight Full Pressure Suit.



Up, up—100 miles up at fantastic speeds—the X-15 is designed to carry man to the fringe of earth's atmosphere. Landing demands the top tire performance which B.F.Goodrich Fabric Tread Tires can give. Cross-section shows how nylon laminates are built into tread stock to reduce rubber distortion under load, equalize modulus between tread and carcass and check formation of "shock waves."

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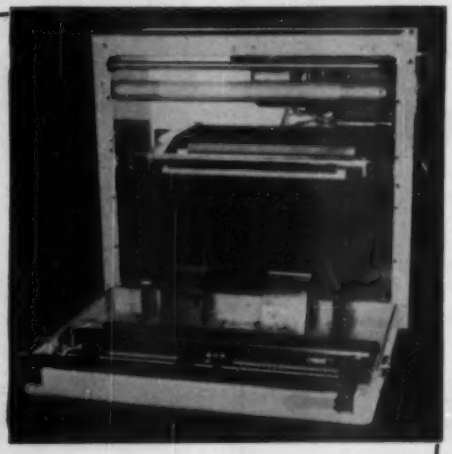

The RX-51 Data Plotter records 1024 points, spaced one hundred per inch, across a 10⅞ inch sheet of electrolytic Hogan FAXPAPER at paper speeds up to 10 inches per second. Over one million separate points can be printed per second.

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at the viewing ports hadn't pointed it out.

Oxygen is recirculated through the laboratory suit and a barium hydroxide carbon dioxide absorber at 20 cu. ft./min. by an eight-bellows pump on a V-8 engine block.

Flow requirement was set by need to carry off body heat. Breathing requirement is much less. Oxygen enters the suit at a temperature of about 49F and leaves it at about 67F, but the experience was one of extreme heat because of high relative humidity. Thin persons are more comfortable in the laboratory suit because perspiration evaporates more freely. Oxygen has to be added to the recirculating system at a rate of about four liters per minute because of absorption by the body and loss from pumps and ducts in the system. Leakage into the chamber is negligible, even to a detector which will respond to a leak rate of a thimble of helium per year.

Litton scientists are confident that they can make a big improvement in the ventilation and dehumidification devices for the advanced lunar system. They expect to continue using evaporative cooling by perspiration but will collect moisture from the suit atmosphere and dump it outside at a higher rate than is now done with the umbilical system in the laboratory. This can be done without increasing oxygen leakage significantly.

Vapor Jacket

While no external vapor jacket will be needed in space, Hansen says it will probably be necessary to wear a lightweight aluminized jumper or some other outer garment which will help maintain a reasonable temperature in the suit by controlling radiated heat balance. Protection against ultra-violet and nuclear radiation and meteorite showers also may be needed. Litton is about to start a contract program of materials research in the space chamber using simulated solar radiation against fabrics and other materials in a vacuum. Hansen expects Litton to learn much of value to the lunar suit program from this project. Tests are expected to cover the solar spectrum thoroughly.

Litton scientists interested in the suit program are also watching the results of cosmic ray studies using satellites and sounding rockets. Since there is little or no atmosphere on the moon, incoming cosmic primaries must impact directly upon its surface, creating isotopes which emit outgoing secondary radiation. This secondary radiation may prove to be an important problem for lunar suit designers. The primaries themselves also deserve consideration. The danger here is the generation of secondary particles when the primary cosmic ray penetrates the suit. It may

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be best to use materials such as aluminum which have low mass and therefore low generation of cosmic secondaries.

Hansen predicts that if men are in space or upon the moon for any prolonged period, there will be some casualties from micrometeorite impacts. Since these arrive with velocities up to 40 miles per second and energy is a function of the square of velocity, it is probably impossible to protect against the larger ones, though to some extent it may be possible to take advantage of terrain for this purpose.

Very tiny particles are undoubtedly far more common and therefore a greater hazard. Hansen believes a portable shelter may be a better defense against these than anything which might be incorporated in the suit.

Fairey Producing Nuclear Components

London—Quiet entry of Fairey Aviation, Ltd., into the nuclear engineering field about 10 years ago has grown to a major portion of the company's total effort today.

Biggest production output is fuel element containers built for the United Kingdom Atomic Energy Authority. Second largest output is heavy steel and aluminum components for reactors or other nuclear facilities.

The company decided to diversify its activities shortly after the end of World War II, when British requirements for military aircraft—Fairey's prime product since 1915—were drastically reduced. Part of this diversification program produced the Rotodyne, another part the Fireflash and other guided missiles. A third part was devoted to nuclear engineering because of the challenge it posed to Fairey's high-caliber technical teams.

Supporting the production of nuclear components has led Fairey into a variety of sidelines, including the design and development of highly specialized machine tools, investment casting in high-strength steels, and the machining and handling of beryllium, a particularly toxic metal.

Fairey is also part of Atomic Power Constructions, a group of companies specializing in the design and building of nuclear power installations. Fairey's particular activity within the framework of this organization is the reactor engineering.

Other company work now in progress in the nuclear field includes design studies for non-power producing units, such as a heavy-water separation plant, and experimental work on design, manufacture, erection and commissioning of experimental reactor equipment for the Authority.

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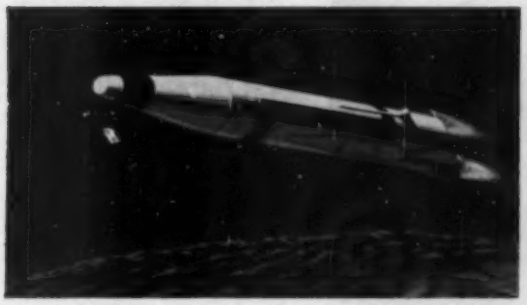
men in two of its most vital weapon systems—the B-70 bomber and the F-108 interceptor.

For though the Strategic Air Command will have squadrons of intercontinental missiles at its command, it will need the B-70 to balance its deterrent power. Aptly named the Valkyrie—for the maidens of Norse mythology who roamed the skies above the battle, deciding its outcome—the B-70 will skirt the edge of Space at 2,000 miles an hour. It will have the range to reach any target...can launch its missiles from afar at enemy ground defenses or the target itself.

And though the Air Defense Command will have a battery of deadly counter-missiles, it will need the 2,000-mph F-108 long-range interceptor. For the enemy must also rely on manned weapon systems for precision bombing. The F-108 Rapier can meet him a thousand miles from our borders...identify him...destroy him.

North American Aviation, Inc. is weapon system contractor for the B-70 Valkyrie and the F-108 Rapier. The best qualified companies in America, large and small, are subcontractors. Work on both these vital projects is already well underway.

AMERICA NEEDS BOTH FOR A BALANCED DEFENSE



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FULL-PRESSURE flight suit worn during flights of the North American X-15 research aircraft is tested on centrifuge (left) at Wright Air Development Center. Dr. Edwin Vail is wearing the MC-2 suit made by the David Clark Co. Same suit is at right.

Full-Pressure Suits Refined for Comfort

By Barry Tully

New York—Full-pressure flight suits, developed for today's high performance fighter and research aircraft, will satisfy the pressurization demands of space flight, but habitability problems remain to be solved.

The National Aeronautics and Space Administration will draw heavily on the experience of the Air Force and the Navy, particularly the Aero Medical Laboratory at Wright Air Development Center, in choosing the type of suit to be worn by Project Mercury astronauts.

Suit Competitors

Competitive full-pressure Mercury suit designs are being evaluated at the Aero Medical Laboratory at WADC. Companies involved in this competition include:

- **David Clark Co.,** Worcester, Mass., producer of the X-15 suit, will deliver five suits to WADC for evaluation under a $100,000 contract. The first of the suits has been delivered and it is being used to acquaint the astronauts with pressure suit characteristics.
- **International Latex Corp.,** Dover, Del., also has delivered the first of five full-pressure suits to be made under a $100,000 contract.

In addition to the above two pressure suits, the Navy Air Crew Equipment Laboratory has delivered one of its Mark IV full-pressure suits to WADC for study in connection with the Mercury program. The B. F. Goodrich suit, designed for operational use by

CAPT. LEROY G. COOPER, USAF, Project Mercury astronaut, wears a full-pressure suit for familiarization. Suits worn on actual flights will be individually fitted.

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fighter squadrons, will be studied by the Aero Medical group.

The military services now are primarily concerned with protecting flight crews of present and planned high performance aircraft in the event of decompression through loss of cockpit pressure or bailout. This requires a pressure suit that will inflate automatically and maintain its pressure until the aircraft reaches a safe altitude (35,000 ft.) or completes its mission. A full-pressure suit capable of performing this function will meet the requirements of space flight as regards pressurization.

Comfort Factor

Pressure suits intended for space travel must, in addition to maintaining pressurization, support the man and permit him to perform necessary operations for extended periods of time. In this respect comfort is very important. An uncomfortable suit would become unbearable in a day or so (see p. 292). In general, pressure suits must:

- **Supply breathing oxygen** and pressurizing and ventilating air.
- **Permit communication** and protect the body and head.
- **Allow ease of movement** and quick donning.
- **Provide stability** under space flight conditions.
- **Permit feeding** and elimination.

The highest pressure altitude at which man can exist without pressurization is 45,000 ft., above which aeroembolism (altitude decompression sickness) takes place. Even at this altitude, pressure breathing of 100% oxygen is necessary. Pressurized cockpits can take pilots above this altitude but the threat of rapid decompression due to structural failure, loss of pressurization due to flameout or other means, or bailout, demands that full- or partial-pressure suits be worn above 45,000 ft.

Pressure suits are designed to maintain a pressure altitude of 35,000 ft. (3.5 psi.) or lower because at that altitude 100% oxygen does not require pressure breathing.

In altitude chamber tests, suits demonstrate the ability to come to full 3.5 psi. pressure in 60 milliseconds in the event of rapid decompression.

Air Force pilots flying Lockheed F-104s and other high performance aircraft wear partial-pressure flight suits. These suits are made of tight-fitting fabric with an inflatable tube running down the torso and the extremities. Upon decompression, the tube is inflated to increase the fabric pressure on the pilot's body. This suit has been worn in a low-pressure chamber at a

NAVY Mark IV, B. F. Goodrich pressure suit, is operational with fleet squadrons. Suit, which costs $3,000, affords cold temperature as well as high altitude protection.

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NAVY Mark III full pressure flight suit has larger neck ring affording less neck mobility than later models. Gold fabric surface provides heat protection.

simulated altitude of 198,000 ft.

The Navy is using the Mark IV full pressure suit, which has been developed by Goodrich.

The suit is worn by pilots of a fighter squadron flying Chance Vought F8U-1 aircraft and by pilots testing the McDonnell F4H and North American A3J.

The Navy says that it went to the full-pressure suit because of its greater protection from aeroembolism, better wearer comfort and more mobility when pressurized. When the partial-pressure suit is pressurized it is quite uncomfortable to wear due to the heavy fabric pressure which cannot be distributed equally over the body surface. The Mark IV suit also provides omni-environmental protection in that it retains body heat in the event of cold water immersion.

Both the Air Force and the Navy have had incidents where pilots had saved their aircraft after loss of cockpit pressurization only because they were wearing full- or partial-pressure flying suits.

Navy says that with its new suit pilots have managed to save planes after decompression in situations where pilots in partial-pressure suits have ejected. Both services agree that the suits have more than paid back their development

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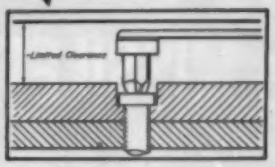

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costs in terms of aircraft and pilots saved.

The double safety concept of pressurized cabin and a suit that can be pressurized in an emergency will be carried on in space vehicles. This will permit the man to wear the suit in the more comfortable, unpressurized condition. The suit, however, must enable the man to perform his control and other operations when it is pressurized. Providing this mobility has proved to be one of the difficult problems in pressure suit development.

Pilots flying the North American X-15 research aircraft are wearing a full-pressure suit developed by the David Clark Co. This suit employs a "slip-knit" nylon fabric which forms a pressure capsule yet allows freedom of movement. The outer cloth is aluminized for protection against heat. The Navy Mark IV suit has a Neoprene-coated inner layer which has a knit stretch fabric tailored into the shoulder, arm and crotch sections. A nylon adjustment strap added to these sections permits individual sizing.

Suits are entered by means of zipper openings, either diagonally across the chest or vertically as with conventional flight suits. Pressure sealing zippers also are used to fasten the gloves and socks to the suit. Palm straps across the glove palms prevent the gloves from ballooning and enable the wearer to perform manual operations.

In addition to pressurization, the suits must be ventilated for wearer comfort. This is accomplished by bleeding air through ducts in the suit to the wrists, ankles, crotch and at the neck. Ventilating air is normally exhausted from the suit; however, in space applications the air will be regenerated as will the breathing air.

Development of pressure suit helmets has proved to be a project in itself. Helmets must be reasonably lightweight yet provide for head protection, oxygen and carbon dioxide exhaust, communication heat removal, vision, neck mobility, and integration with the suit itself. Before the advent of extended space missions, the problem of feeding while pressurized will have to be solved.

Early Pressure Helmets

Early pressure helmets had the tendency to become fogged from the wearer's breathing. Present helmets pass breathing oxygen across the visor to keep it fog free.

Helmets are divided into a face section containing 100% oxygen and a pressurized air section. A face seal prevents gas flow in either direction. Carbon dioxide is exhausted from the face plate section into the suit.

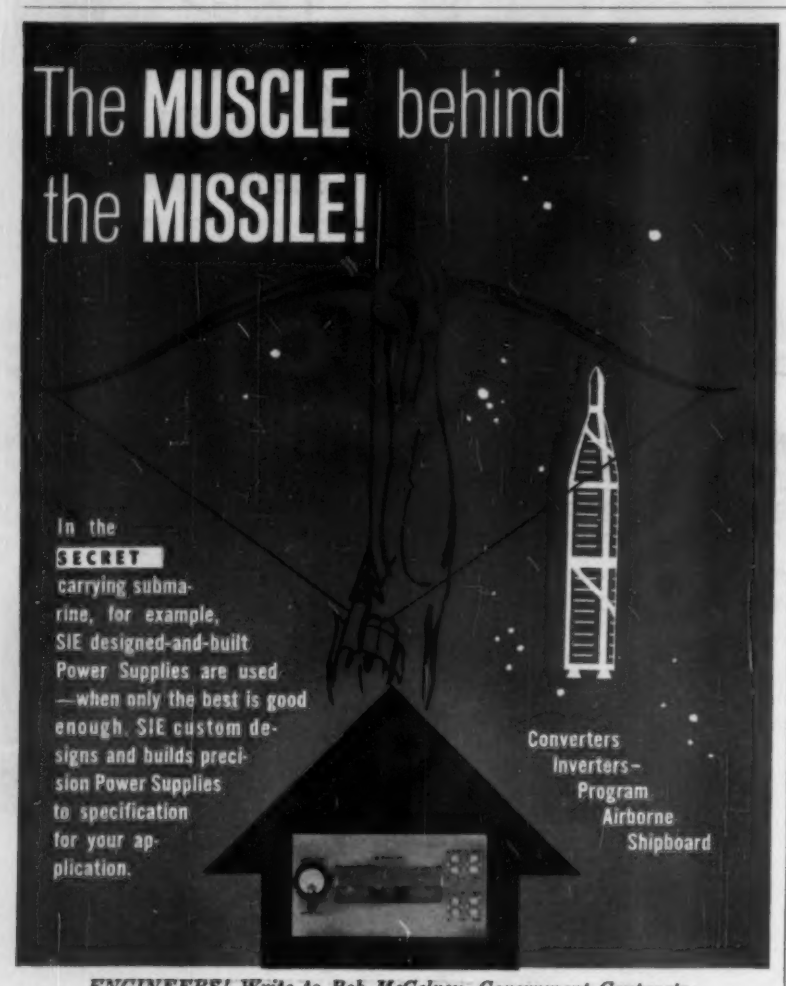
One problem in full-pressure suit design is that the helmet has a tendency to rise when the suit is under pressure. The Navy Mark IV suit prevents this rise and maintains neck mobility with a cable arrangement attached to the neck ring.

Weight Reduction

Pressure suit weight has been reduced to approximately 20 lb. Some of the first full pressure suits weighed as much as 100 lb. Another area where significant improvement has been made is in the design of neck rings, which have been made smaller and lighter while retaining sealing characteristics.

With increased space exploration, more specialized pressure suits will become necessary. A suit intended for use in a manned space station, for example, would not be suitable for lunar exploration. Considerations such as the degree of gravitational force, if any, and the wearer's job will determine design.

The control of body movement in a weightless environment, for example, will require small jets, since leg movement will be of no value. Retrojets will be necessary to halt any motion that is begun. One plan suggests using foot-actuated control jets in order to utilize the feet and legs and to free the arms and hands to perform other functions.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PARACHUTE being tested in NASA's Lewis Research Center wind tunnel is designed by Cook Research Laboratory to stabilize B-58 crew recovery capsule in early deceleration phase.

Electronic Data Processing Saves Manpower in B-58 Quality Control

By Erwin J. Bulban

Ft. Worth—Caught in a squeeze of higher quality control requirements imposed by the B-58 Hustler Mach 2-plus bomber's complex design and structure and the necessity for maintaining the project within sharply defined budget limitations, Convair-Ft. Worth Division engineers are making increasing use of electronic data processing techniques to solve vital statistical problems.

Use of electronic data processing by quality control here has gained momentum in the past six months, following a Convair-Ft. Worth study that indicated that the cost ratio of man-hours to computer costs for solving statistical problems is 5.6:1, based on the use of the International Business Machines Model 650 or an equivalent computer.

Significant manpower and material savings made thus far are encouraging quality control to study further development of the program to extend its mission directly to factory working areas.

Current computer use is saving the division considerable money by providing Quality Control Manager J. Y. McClure's staff with these benefits:

- **Elimination** of a substantial portion of the time normally spent by engineers at desk calculators, allowing them considerably more time to devote to actual quality control engineering effort.
- **Reduction of time** required to finish quality control engineering studies; often process improvements can be made two to three weeks earlier than

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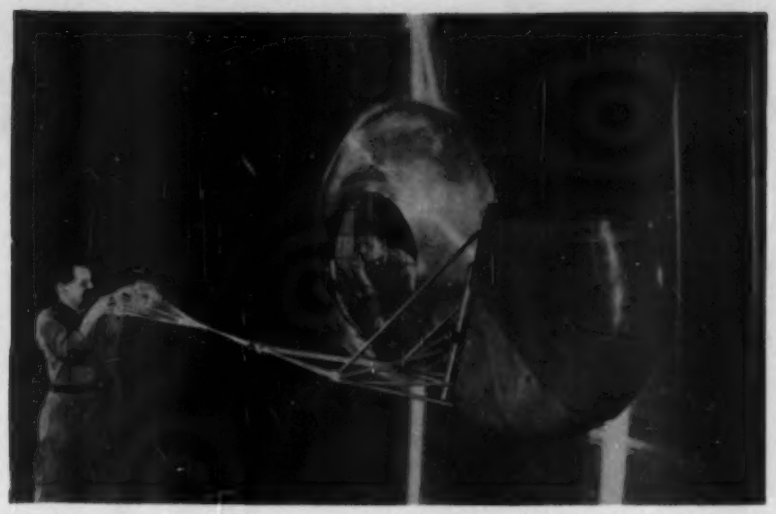


STANLEY AVIATION B-58 crew recovery capsule model is ¼ scale. After Cook Research parachute (see p. 315) is deployed, large recovery parachute is activated for landing.

had been possible in the past.

• **Permits use** of valuable but complex statistical methods that were impossible or impractical due to the time they would have required.

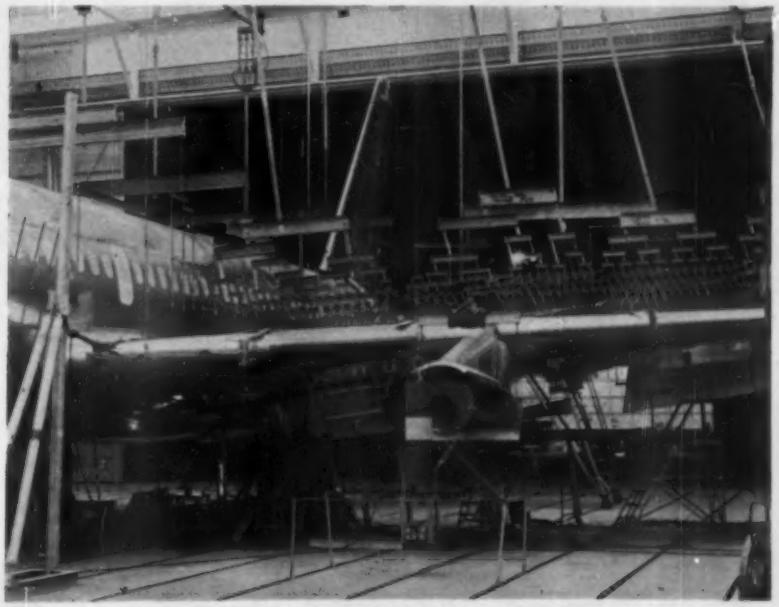
• **Reduces manpower** requirements for routine calculations needed for weekly and monthly quality reports, which had been up to a month or six weeks late.

Future plans for the computer-assisted quality control program envisages the use of electronic readers in the plant throughout working areas. Data on rejects will be fed directly from material review stations to tape. Information on rework required on parts will also be taped by the employe doing the rework.

Match-Merged

Data will be match-merged from labor distributions tape to the quality control tape. Scrap cost in hours and raw material costs will also be available on either tape or punched cards.

System will provide quality control with near-instantaneous readout providing up-to-date data for nearly all quality control reports concerning scrap



Convair 880 Undergoes Stress Tests

Second Convair 880 turbojet transport receives simulated flight stress tests at manufacturer's new $2 million High Temperature Structures Research Laboratory, San Diego, Calif.

HOW

Product Improvement Program

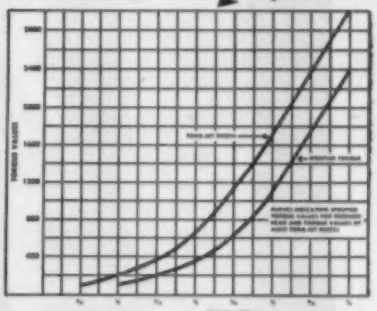
improves performance

TORQ-SET
(NAS 1100 and 2000 SERIES)

Look here

This is the famous TORQ-SET wrenching socket which makes possible the use of a single design for all fastening locations. It combines the ease of power driving at extremely high torques with easy removal.

Look here



This chart shows how TORQ-SET delivers torque values well in excess of specified torque requirements. A TORQ-SET ¼" diameter bolt, designed for aircraft application, delivered an unheard-of torque of 450 inch pounds . . . another example of how American's Product Improvement Program works for you.

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Product Improvement Program

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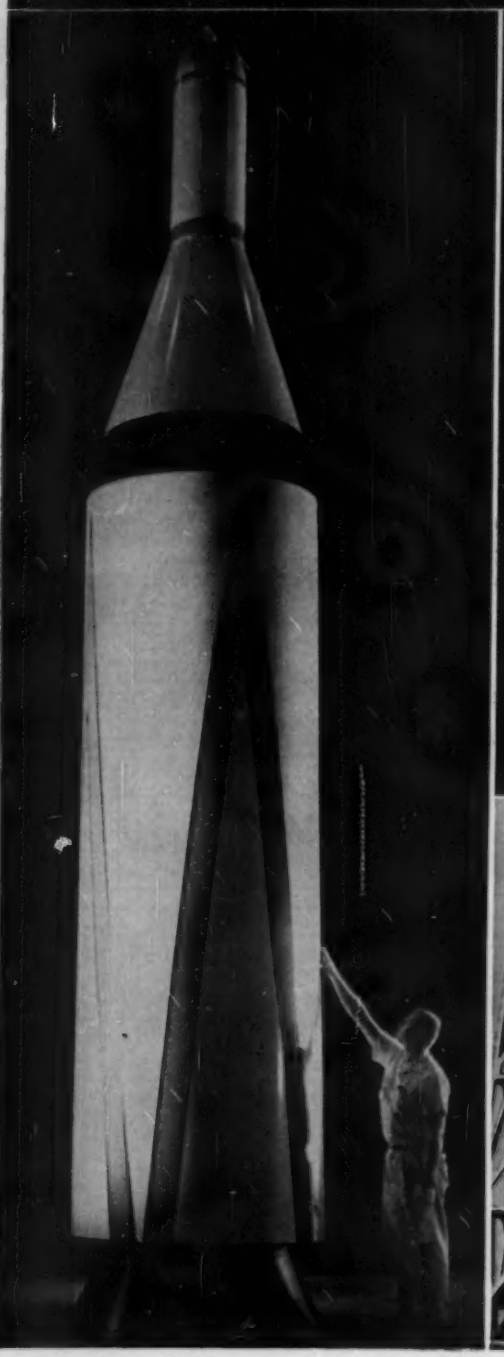
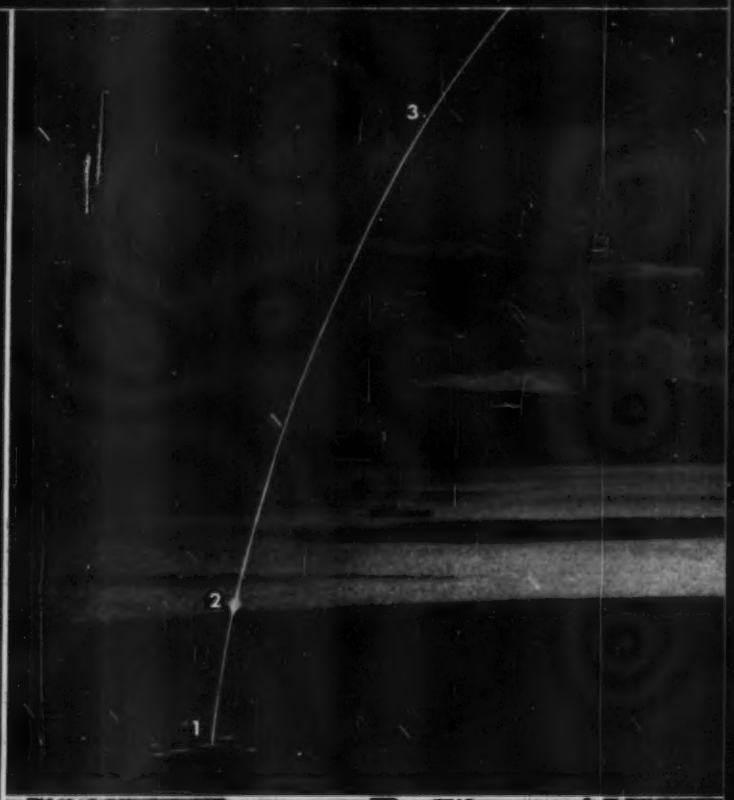
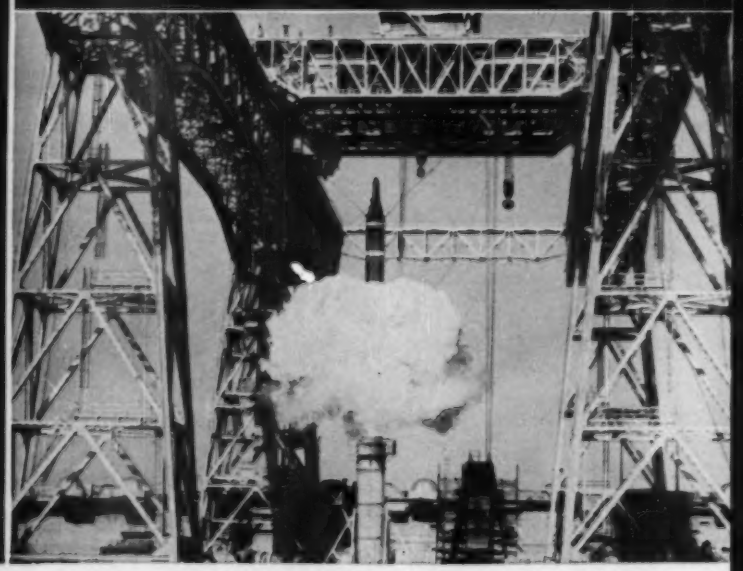
The Lockheed-developed U. S. Navy POLARIS:

Missiles launched from ocean depths







Left: *"Operation Sky-Catch" tests,* conducted jointly by U. S. Navy, Westinghouse and Lockheed, reveal effects of launch stresses. To prevent damage to POLARIS test missile components, huge overhead assembly catches it in mid-air.

Far left: *Carrying awesome destructive power,* Navy's POLARIS is markedly smaller than other U. S. ballistic missiles of same range. To enable one submarine to carry many missiles, Lockheed scientists achieved miniaturization breakthroughs on all major systems of POLARIS.

Above: *Propulsion system firings* light up night sky at Lockheed Missiles and Space Division's 4000-acre test base in the Santa Cruz mountains, Calif. A nearby vertical test stand permits simulated flights of complete POLARIS missiles, to test their propulsion and guidance systems.

Left: *Nuclear powered U. S. Navy sub* (1) launches solid-propellant POLARIS missile which erupts from ocean depths (2)—then rockets its way on a ballistic missile trajectory high above the earth's atmosphere (3) into outer space. Re-entering the atmosphere (4) the re-entry body of the POLARIS plunges earthward to destroy its target (5).

Launching an IRBM from submerged submarines involves technological developments that are unique in ballistic missile history.

As POLARIS Missile System manager and prime contractor, Lockheed's Missiles and Space Division is responsible for coordinating all phases of its design, development, and production.

The POLARIS, a solid-propellant missile, will be operational in 1960—ahead of schedule. The operational missiles will be delivered to U. S. Navy submarines in Lockheed ready-service transporters under controlled humidity and temperature conditions. And Lockheed's ACRE—Automatic Checkout and Readiness Equipment—will maintain the constant ready-to-fire capability of POLARIS missiles, right up to the moment of launch.

With an ultimate range of 1500 nautical miles, the POLARIS will become one of the most formidable deterrent weapons ever devised. For any significant military target on earth will be within range of its nuclear warheads.

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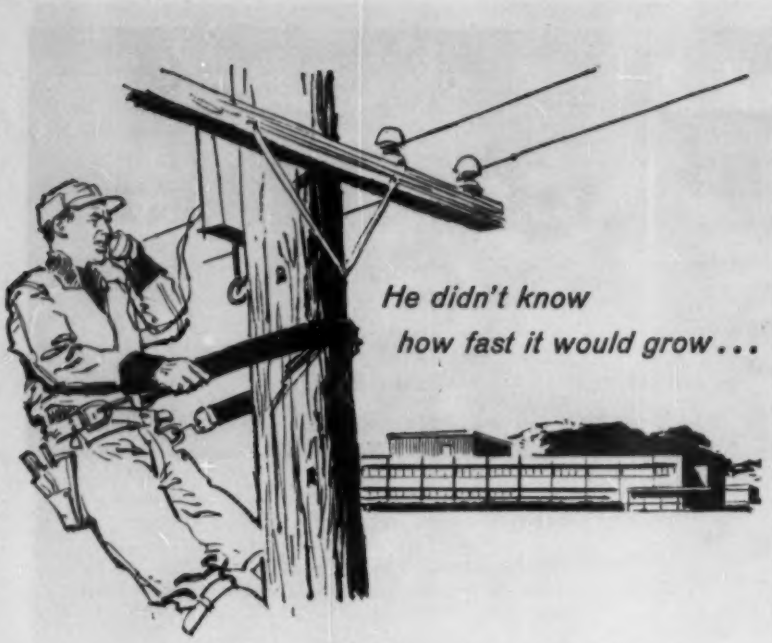


"CALL ME ON **NOrmandy 5-7766**"

Ten months is but a wink of the eye in the industrial timetable—usually. But Bendix Systems Division, which moved into its permanent quarters in Ann Arbor just ten months ago, is adjusting to a growth pattern even more remarkable than expected.

The new phone number—NOrmandy 5-7766—marks a major step forward for an organization playing a vital role in the development of America's weapons systems. It symbolizes the thirty telephone lines now needed to handle incoming calls, as compared to only ten which were deemed necessary a few months back.

These thirty lines connect the 27 divisions of the world's most diversified engineering firm with their new system center, the Bendix Systems Division. They also make the Division's capabilities immediately available to government agencies and weapon system contractors all over America. A call from Washington's LIberty exchange or Dayton's CLearwater exchange can get same-day action from a complete team for the planning, development, production and operation of advanced weapons systems.

"The new lines which put you in touch with the Bendix Systems Division give direct access to top scientific and engineering specialists in the weapon systems field," says Dr. R. D. O'Neal, Division Manager. "These lines also harness the complete engineering capabilities of the entire Bendix Aviation Corporation."

NOrmandy 5-7766 is now the key number to the men who call the plays on the nation's most important systems projects. A growing team in this gleaming new systems headquarters is ready to move in the wink of a switchboard light. Opportunities are available for engineers and scientists looking for a promising and exciting future.

Bendix Systems Division
ANN ARBOR, MICHIGAN

Bendix
AVIATION CORPORATION

and rework, repetitive discrepancies, repetitive conditions, requiring only drawing and reproduction of the necessary charts. Obvious benefits include not only time-savings in compiling such data, but also the ability to more quickly pinpoint trouble areas where a problem may be studied early and necessary changes incorporated to cut losses.

Areas Covered

Three areas in which quality control is using electronic data processing include quality control engineering, vendor quality performance rating and division quality reports.

To point up savings possible using computer analysis on a quality control problem, McClure noted the case where an analytical study of lap shear testing of bonding adhesive was made manually to determine if results from five tests per sample would safeguard quality as well as the 10 tests per sample—then specified in the process standard. Computation was made prior to the time that the quality control group began incorporating computer techniques.

The time required to carry out these computations on a calculator was 65 hr. Had the work been done with a computer, it would have required only one-third of an hour, with a saving in man-hour costs of more than $249.

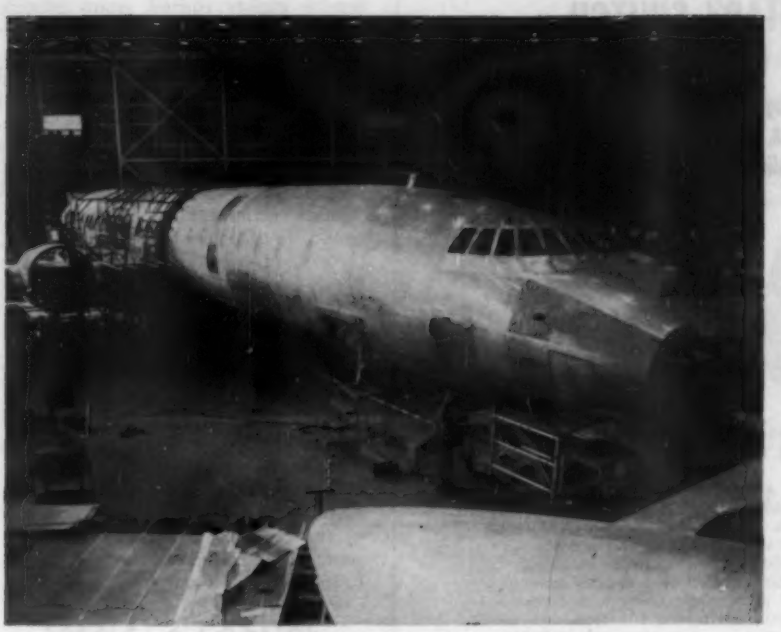
The loss of a week and a half in making the process change—which now saves the division more than $150,000 annually—due to the time lost doing the problem manually, cost Convair some $4,000, McClure estimates.

Practical Application

To determine an equation for the relationship between aluminum etch quality and the strengths of the four chemicals used in the chemical milling solution, Convair used the computer to develop a nomograph which determines when solutions need to be adjusted or changed in order to maintain quality.

Estimated savings per year because losses are cut down: $16,000. By using the computer, calculation time to solve the problem was reduced by 75 hr. and cost of the solution was $25 (one hour of machine time) compared with an estimated $280 for manual calculation. The two-week reduction in time for solution of the problem allowed putting the processing change in effect earlier.

In a problem concerning hot-forming X-2020 aluminum, to determine effects of metal working processes on the physical properties of the alloys, would have required some 176 controlled experiments without use of statistical information. A quality control engineering study cut this to 12 experiments. It would have taken 40 man-hours of manual calculation to develop the statistics required at a cost of $140—



First CL-44 Nears Completion

Airframe of the first Canadair CL-44 turboprop transport is being assembled on the production line in Montreal, Canada. The 150-passenger aircraft is designed to carry a 65,000 lb. payload at almost 400 mph. Royal Canadian Air Force has ordered 12 CL-44s. Seaboard & Western Airlines and Flying Tiger Line have purchased 15 swing-tail CL-44D-4 turboprop cargo aircraft (AW May 18, p. 41).

the computer ran the problem in three-quarters of an hour for $18.75.

Most significant is not that the computer provides these time and cost savings—but that these savings permit the staff to take on and solve problems that might otherwise have to wait or not be capable of solution on the basis of being backlogged for lack of manpower to handle them.

Convair-Ft. Worth's system of vendor performance rating was especially designed with the use of a computer in mind. Availability of the computer enabled the company to economically combine principles of incurred quality expense and per cent defective items on one report. The advantage is that per cent defectives now have a qualifying expense value, permitting the quality control department to place corrective action emphasis where most needed. Also, a vendor's performance can be compared with other vendors in a like material class. Each vendor's incurred quality expense—cost generated by Convair above the normal cost of accepting good material—and per cent defectives is computed and compared with the average incurred quality expense and per cent defectives of the group of vendors supplying like material.

Depending upon a relationship between actual vendor performance and the group average, the vendor is classed in one of three groups established by Convair—A, B or C vendors. The

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Weighs only
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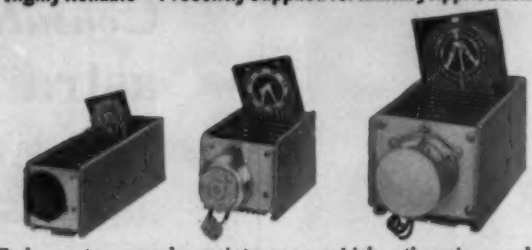
1 1/16" x 1" x 1 7/8"!
The new Model GMA Accelerometer is a fluid damped, potentiometer output instrument, particularly suited for flight and fire control and telemetering applications. Now in production.
Brief Specifications
Range: ±0.5 g to ±100 g's
Natural Frequency: 12 cps to 75 cps
Linearity: ±1% of full scale
Damping: Nominally 0.7 of critical at 75°F.
Temperature: Operates to specifications between −20°F and +185°F.
Vibration: 10 g's, 10-20,000 cps, any axis
Shock: 50 g's for 7 ms, any axis
MODEL GMA

Send for complete specifications to the Instrument Division:
Genisco INCORPORATED
2233 Federal Avenue, Los Angeles 64, California

CIRCLE NO. 321 READER SERVICE CARD

UNIQUE DESIGN ROTARY SWITCH— 5-SECOND WAFER REPLACEMENT

No Unsoldering or Disassembling . . . No Wire Removing . . . Simply Lift out Any Wafer & Replace Instantly . . . Highly Reliable—Presently Supplied for Military Applications



Reduces to seconds maintenance which otherwise could take a full day or more, saving valuable time. New design obsoletes old switches.

Switches are available in sizes approx. 2" x 2", 3" x 3" and 4" x 4" with lengths to accommodate up to 36 wafers. Virtually unlimited choice of switch circuit configurations. All connections are to a single bank of receptacles and are conveniently accessible from one side of the aluminum housing. Contacts are silver, gold or rhodium plated on a copper base. Wafers can be made to include printed circuitry and components in addition to their normal switching function.

Switches may be manually, motor or solenoid operated for use in any rotary selector switch application. Manufactured under Tabet U. S. Patent No. 2,841,660. Other U. S. and foreign patents pending. Write for details today.

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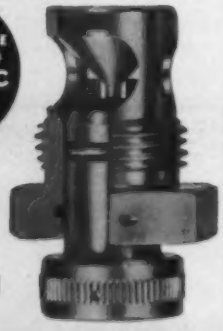
Tedeco Bayonet Type Self-Closing Magnetic Drain Plugs make routine inspection easy. An inward push and slight turn removes plug. Valve closes automatically. For drain or refill, bayonet connection hose available.

TEDECO BAYONET TYPE SELF-CLOSING MAGNETIC DRAIN PLUG



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TECHNICAL DEVELOPMENT CO.
Glenolden, Pa. — LUdlow 3-3330

vendor quality control group concentrates immediate corrective action efforts on the C-class suppliers.

The report is directed by a salaried employe and requires about one-half his time, the rest being spent on special analysis of vendor data in connection with the corrective action data. A full-time clerk is also used. Using only manual computation, such a report would be prohibitive, Convair believes, since it estimates that one salaried employe and six full-time clerks would be required full-time—and then the report would be 30-60 days late.

The computer also provides the company with its monthly and weekly division quality reports, which show the amount of scrap and rework by dollars and hours lost, posted as to the frequency of hours lost to actual hours expended. This data is shown by total division, by department and by contract in the monthly report—the weekly report goes one step farther to show performance by cost center.

WHAT'S NEW

Publications Received

Filler Metals for Joining—by Orville T. Barnett, Pub.—Reinhold Publishing Corp., 430 Park Ave., New York 22, N. Y. $7.00; 244 pp. A reference for selecting the proper filler metal for any metal joining situation. Outlines the best choice where several filler metals are offered for a single application.

Semiconductors—by N. B. Hannay. Reinhold Publishing Corp., 430 Park Ave., New York 22, N. Y. $15.00; 767 pp. Detailed analyses of important semiconducting materials. The chemical aspects and the physics of semiconductor behavior are treated. An introduction by leaders in semiconductor research precedes each chapter.

Aircraft Weight & Balance Control—by Henri G. D'Estout. Aero Publishers, Inc. 2162 Sunset Blvd., Los Angeles 26, Calif. $3.25; 128 pp. This new, completely revised and enlarged edition covers the general principles of aircraft weight and balance control, basic measurements and computations, weight shifting and alterations, weighing and loading procedures for aircraft.

Tomorrow the Moon—by Abraham & Rebecca B. Marcus. Prentice Hall, Inc., 70 Fifth Avenue, New York 11, New York. $3.50; 150 pp. In simplified, nontechnical explanations this book answers many questions pertaining to space travel. Diagrams are used to help visualize scientific laws in action. A book for adults who would like to know more about the science of space.

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INSTRUCTIONS

1. Circle key number listed at bottom of advertisements.

2. Write in page number for ads with no key number.

3. Fill in your name, company, address and title.

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Reports Available:

The following reports were sponsored by the Office of Technical Services, United States Department of Commerce, Washington 25, D. C.

VCI Oils–Properties and Proposed Quality Control Tests–by R. L. LeMar, Rock Island Arsenal, U. S. Army, June, 1958. $1.75; 59 pp. (PB 151122).

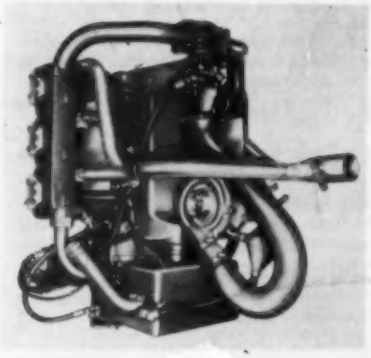
Mechanism of the Oxidation of Hydrocarbons–by C. E. Boord, Ohio State University for the Air Force Office of Scientific Research, April, 1958. $2.75; 120 pp. (PB 151016).

Effects of Metals on Lubricants–by J. B. Christian, Wright Air Development Center, U. S. Air Force, May, 1958. $1.00; 31 pp. (PB 151446).

Proceedings of the Inter-American Symposium on the Peaceful Application of Nuclear Energy–U. S. Atomic Energy Commission, May, 1957. Two books sold as a single set–$6.00. Book 1 contain 368 pp.; book 2, 253 pp. (TID 7554).

An Engineering Study of Aircraft Crash-Fire Prevention–by R. B. Jones, R. G. Diquattro, and R. G. Towle, Walter Kidde & Company, Inc., for Wright Development Center, U. S. Air Force, June, 1958. $2.75; 129 pp. (PB 151455).

A Study of Experimental Techniques for the Measurement of Static and Dy-



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Turbosupercharged Franklin 6VS-335 engine, designed for light helicopter installation, maintains sea level rating of 225 hp. to 10,000 ft. and weighs 360 lb., only 40 lb. more than Franklin 200-hp. and 210-hp. powerplants, manufacturer notes. Engine is designed so that it can fit into existing Franklin-powered Bell and Hiller helicopters with airframe or engine mount structural alteration. A conversion kit will be available to provide turbosupercharger feature in current 200-hp. and 210-hp. Franklins.

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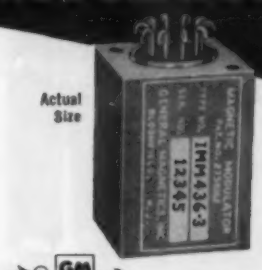

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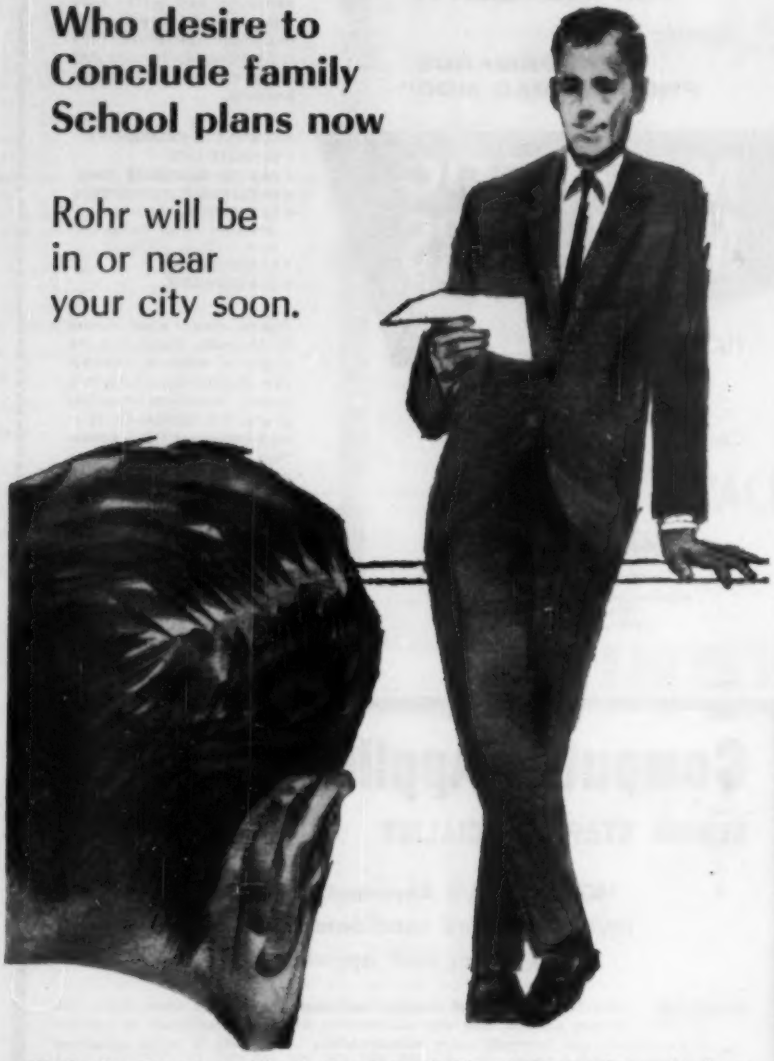

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namic Tire Parameters Related to Nosegear Shimmy—by A. G. Fonda, Cornell Aeronautical Laboratory, Inc., for Wright Air Development Center, U. S. Air Force, August, 1957. $1.75; 66 pp. (PB 151254).

An Elastic Tube Theory of Pulse Transmission and Oscillatory Flow in Mammalian Arteries—by J. A. Womersley, Wright Air Development Center, U.S. Air Force, Jan., 1957. $2.75; 135 pp. (PB 151356).

Extending Human Tolerance to Heat by Prior Body Cooling—by J. H. Veghte and P. Webb, Wright Air Development Center, U.S. Air Force, Sept., 1958. $.50; 20 pp. (PB 151469).

Psychologic and Bioelectric Assessment of G-Suit Protection—by A. J. Silverman, S. I. Cohen, G. D. Zuidema, and L. L. Vickery, Wright Air Development Center, U.S. Air Force, Oct., 1958. $.50; 13 pp. (PB 151476).

The Demonstration of Succinic Dehydrogenase in Single Tissue Elements of the Central Nervous System—by R. L. Friede, Wright Air Development Center, U.S. Air Force, Aug., 1958. $.50; 11 pp. (PB 151491).

Metal-Reinforced Ceramic Radome—by L. M. Atlas, Armour Research Foundation of Illinois Institute of Technology for Wright Air Development Center, U.S. Air Force, Oct., 1958. $1.25; 42 pp. (PB 151504).

Metal and Self-Bonded Silicon Carbide—by R. E. Wilson, L. B. Coffin, and J. R. Tinklepaugh, Alfred University for Wright Air Development Center, U.S. Air Force, Jan., 1955. $1.25; 46 pp. (PB 151115).

Low Cycle Fatigue of Notched and Unnotched Specimens of 2024 Aluminum Alloy Under Axial Loadings—by T. H. H. Pian and R. D'Amato, Massachusetts Institute of Technology for Wright Air Development Center, U.S. Air Force, Feb., 1958. $2.25; 87 pp. (PB 151355).

Phase Relationships in the System Iron-Aluminum-Oxygen—by L. M. Atlas and W. K. Sumida, Armour Research Foundation of Illinois Institute of Technology for Wright Air Development Center, U.S. Air Force, Feb., 1957. $1.50; 55 pp. (PB 151000).

Cyclic Creep Buckling of Integrally Stiffened Aluminum Alloy Panels—by C. W. King and B. J. Nolan, North American Aviation, Inc. for Wright Air Development Center, U.S. Air Force, Apr., 1958. $2.75; 124 pp. (PB 151515).

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basic studies of submarine phenomena and their interactions with all possible search techniques (radar, IR, etc.); theoretical laboratory and field explorations of new, more general detection systems.

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basic studies of acoustics in nature; underwater acoustics; submarine noise; echoes and signal correlation employing information and communication theory.

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HYDRODYNAMICS:
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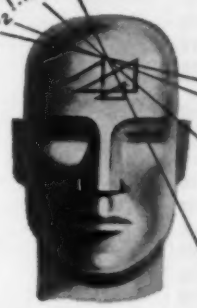

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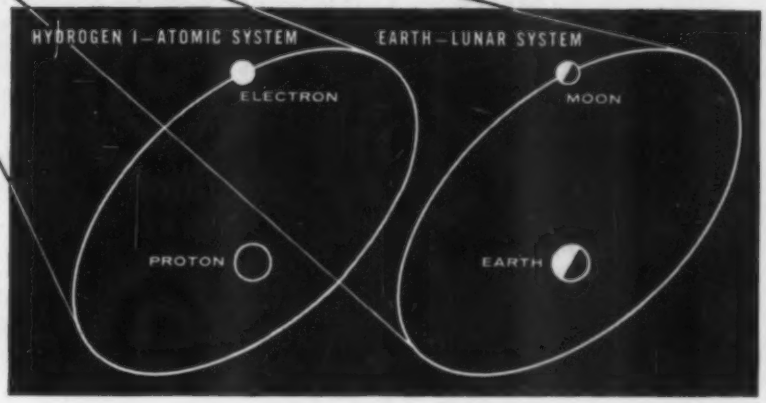

BOLD MINDS

THROUGHOUT HISTORY..... **BOLD MINDS** have sought to understand the forces at work in the universe, and as they developed working hypotheses, endeavored to turn all knowledge to their own purposes, devising philosophical and mechanical systems of their own.

As old hypotheses become inadequate or untenable, thinking men devise new ones. So the concept of a "flat" world has changed to an oblate orbiting spheroid—mere speck in a vast and expanding universe; so "empty" formless space is regarded as a curved continuum occupied by random knots of turbulence (creating the new branch of mechanics—hydromagnetics).

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- Systems Engineering
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- Receiver & Transmitter Design
- Airborne Navigational Systems
- Jamming & Anti-Jamming
- Miniaturization-Transistorization
- Ranging Systems
- Propagation Studies
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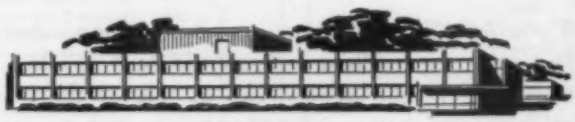

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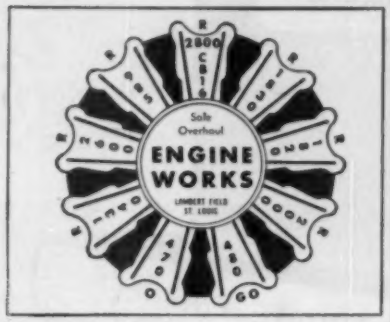

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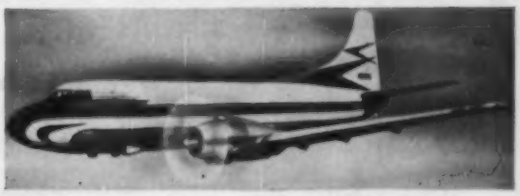

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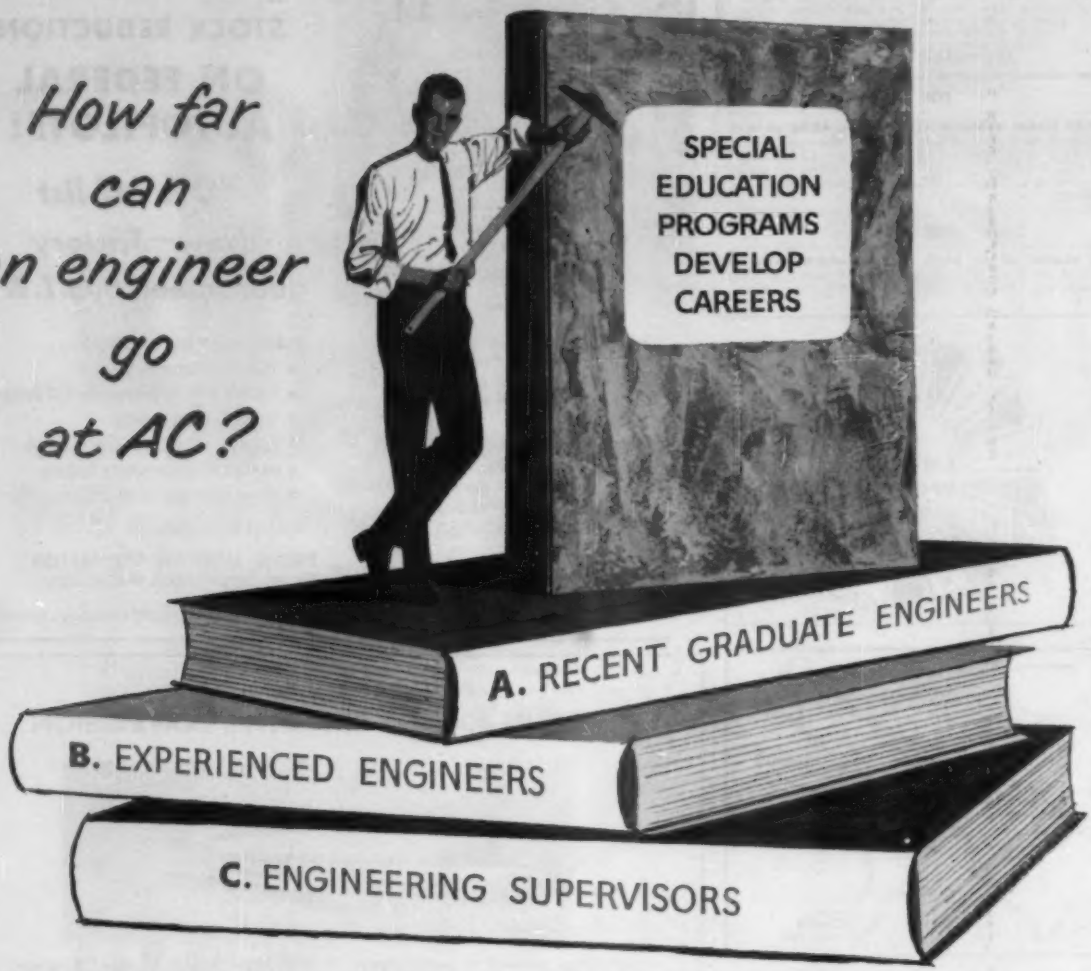

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LETTERS

Company Confidential

Editorially you have cited instances wherein government agencies have attempted to keep technical details, which they believe vital to our country's defense, secret. Your view is that this practice is repressive to our industrial growth in that it denies the latest information to all segments of the scientific community.

Your viewpoint has been interesting to me because it is completely opposite to my own. In my association with various aircraft companies I have found that they are very reluctant to pass along new ideas or processes that might aid competitors. As an example I cite the practices of a major helicopter manufacturer. This company refuses to forward research reports to the rest of the industry. In fact, reports forwarded to them by other aircraft companies are always returned stamped, "Returned Unopened. It is company policy not to accept these reports."

Confidential information controlled by the government is available to any member of industry who has a security clearance. He may obtain it through ASTIA merely by asking. Conversely, just let him try to get access to information labeled, "Company Confidential, Proprietary Information."

WILLIAM G. HALSTROM
Palo Alto, Calif.

In Every Garage

Current publicity and interest in various "levitation" aircraft such as those mentioned in your April 27 issue of AVIATION WEEK seem to indicate a definite need for greater public education into the "facts of life" where such vehicles are concerned. The man in the street seems to have the idea that he will soon be getting into his "Flying Saucer" and dashing off to work at 100 kt. A recent issue of This Week Magazine, which is so widely distributed through Sunday newspapers, showed a military "hovercraft" doing "Flying Saucer" tricks. The only trouble was that the artist failed to show the flying debris which would be caused by such a vehicle. Any idea of being able to walk out to your garage and "levitate" off down the street is something that is going to have to wait for some new development that is certainly not within the realm of present possibilities. In the first place, it would be the garage and not the vehicle that would take off when the engine was started. This would presume that the vehicle had been delivered to the garage during a general evacuation of the neighborhood.

There is no magic carpet phenomenon to such machines, and as long as they must lift themselves by displacing a mass of air equal to their own weight in order to fly their operation is something that is not going to be popular or practical for the average man. Even present day helicopters with their relatively low pressure downwash are prohibitive for use in the average backyard, and after a few experiences of blowing the flowers out of the garden, the bricks off the chimney, and the shingles off the roof, most helicopter operations have been moved to the airports or at least to secluded heliports where the blast, breeze, and noise are acceptable. Visualize, if you will, your neighbor getting up on Sunday morning to fly off to his golf game while you try to sleep-in and you can get some idea of how popular even a helicopter in the garage is ever going to be. Ten years ago the helicopter proponents were going to have a chopper in every garage in 10 years. Today they are still mainly found on the airports, and you still drive an automobile out to the field (pasture) to use one except in unusual circumstances. Now we find a new crop of shortsighted proponents facing similar unrealistic facts, and telling the world that their direct lift aircraft will soon replace the automobile.

We are directly concerned with these matters here at Aerocar, since our goal has been to develop a practical air vehicle that could be put in the garage at home and provide practical, economical air transportation when it was actually desirable or possible to fly. Our studies at the beginning of our development program were not hampered by any preconceived ideas of whether our vehicle would be a helicopter, ornithopter, verti-jet, hovercraft, or fixed wing airplane. They were all studied in detail before the practicability of the Aerocar as presently developed was decided on. Even then, without government sponsorship, it has taken us 11 years to arrive at a practical, foolproof, economical automobile that can fly. However, this has been done and we now have that aircraft in the garage that is still much desired and dreamed of. As it turned out, it is quite conventional and does not rely on any exotic means of flight. It is cheap enough to be owned by a person in moderate circumstances ($10,000). It is economical enough to be operated by the same guy (18 mpg. on the road, and 8 gph. at 100 mph. in flight). It is quiet enough to drive into the driveway at home without waking the neighbors, and it meets all existing FAA and state vehicle codes as it proceeds either by air or road, as your fancy dictates.

We believe the "facts" of verti-jets, hovercraft, and other levitation vehicles, as far as noise levels, blast effects, etc., need to be pointed out in greater detail so that the public will have a better understanding of what to expect in the way of future versions of such machines. Perhaps this will have to await more actual demonstrations of various items of "hardware" which are just now getting to the testing stages. Meanwhile we are, of course, driving our "aircraft" to work every morning, driving it home for lunch, and down the main street daily. We also drive it out to the airport, sprout its wings in five minutes or less and fly off to distant places in less than half the time taken by any other automobile to get to those same destinations. It is all so routine and unspectacular that about the only comment we get is "I'll be darned." Oh yes, the public wants these automobiles that can fly, and we are making every effort to get them into quantity production. We have every hope that this far-more-useful-than-other aircraft will some day be in every garage.

M. B. (MOLT) TAYLOR
President, Aerocar, Inc.
Longview, Wash.

Aviation Week welcomes the opinions of its readers on the issues raised in the magazine's editorial columns. Address letters to the Editor, Aviation Week, 330 W. 42nd St., New York 36, N. Y. Try to keep letters under 500 words and give a genuine identification. We will not print anonymous letters, but names of writers will be withheld on request.

Track-Runways

As airplanes become larger and larger, and atomic energy becomes the possible source of power for large aircraft, some thought should be given to an improved method of takeoff, landing, and ground handling.

The present large airport capable of handling large jet aircraft quite often is very costly to acquire as it requires so much area. Many miles of railroad track could be built for the cost of one 10,000 ft. runway. The terrain may be more rolling for a railroad type of track than a runway and does not have to be as wide.

You may have guessed, I am suggesting railway type of tracks in lieu of the present concrete runways. These tracks would carry a landing platform on which the aircraft would land and have their own source of power, probably electric motors. The electric motors would permit the platform to be accelerated to the speed of the landing aircraft, have electro-dynamic braking, and supplement the power of the aircraft on takeoff. The aircraft would not have any landing gear, a considerable saving in weight and maintenance, but would have latches or fittings to which the landing platform would attach.

The landing platform would be an articulated group of cars or platforms. The most powerful of the platforms would support the airfoil and power section of the airplane, which would probably include the pilot compartment. The cargo or passenger section would rest on a second platform and be quickly detachable from the flight unit. The flight unit could immediately be shuttled back to takeoff position ready for the attachment of another passenger and cargo pod, while the detached load carrying pod is shuttled to the terminal which could very easily be located in the central part of the city.

In the case of atomic power, a minimum of exposure to radiation from the power unit would be controlled by keeping it in the remote landing area at all times when it was not actually in flight.

There should be no such thing as an airport being below landing or takeoff limits, as all landing and takeoffs would be automatic. The pilot would simply monitor all equipment for proper operation. Considering the homing capabilities of the Sidewinder missile along with all the present and projected automatic aids to navigation, an automatic landing system should not be too much of a problem to develop.

D. P. PAYNE, PRESIDENT
Aero-Way School of Aviation
Richmond, Va.

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Mobility is essential to the mission of the Tactical Air Command. Whenever or wherever trouble strikes, TAC must be capable of moving men and materials with speed and safety, regardless of weather or landing conditions. The AN/TPN-12 Ground Control Approach Radar System, now in production at LFE, assures all-weather mobility for the Air Force on virtually any landing strip in the world. Lightweight; portable (by land, sea or air); simple to set up and operate; this highly reliable GCA System has progressed from proposal-to-prototype-to-production in only 10 months time . . . another outstanding example of *Leadership from Experience* by LFE.

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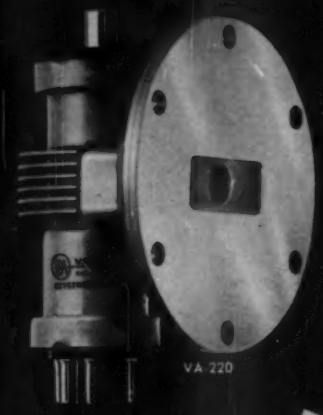

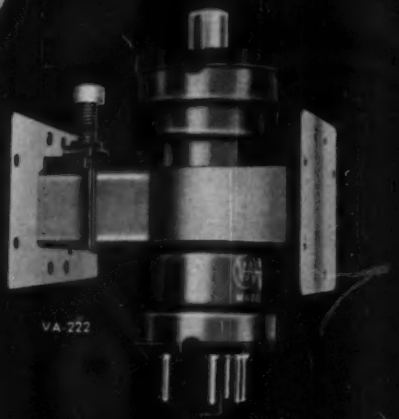

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